JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

Vol. 35 **JANUARY 1943** **No. 1**

Contents

War Emphasis in Water Works Management. By Samuel B. Morris.. 1
Maintenance of Water Supply in Britain Under War Conditions..... 7
Can American Water Systems Provide for Civilian Defense. By Kenneth J. Carl..... 19
Civilian Defense and Public Water Supply. By Gordon E. McCallum.. 27
Maintenance of Public Water Supplies for Civilian Defense. By Daniel W. Evans..... 30
Use of the Emergency Specifications Alum. By Fred E. Stuart..... 34
Substitute Materials in the Water Works Field. By Richard Bennett.. 37
Applications of Metallizing in Water Works Practice. By J. S. Stevens 53
A Superintendent's Nightmare. By M'Kean Maffitt..... 58
Practical Aspects of Guarding Utility Properties. By George A. Hunt.. 65
Plans for Emergency Distribution System Repairs in San Francisco. By George W. Pracy..... 69
Problems Resulting From Plant Expansion and Minimum Standards for Water Plants in the Southwest. By H. J. Darcey..... 71
Wartime Administrative Problems of the Dallas City Water Works. By Homer A. Hunter..... 73
Relationship Between Small Town Water Supply and State Health Department. By Walter A. Reiman..... 77
Emergency Experiences During Flash Floods. By Bernard S. Bush and M. J. Barrick..... 81
Discussion by George R. Taylor..... 87
Discussion by Myles W. Edwards..... 88
Public Health Service Drinking Water Standards..... 93
Abstracts of Water Works Literature..... 105
War Manpower Commission Policy and Manning Tables..... 127
Discharge of Soldiers Over 38 Years of Age..... 133
Selective Service Amendment..... 134
MORALE.....*following page* 134
Coming Meetings..... vi
News of the Field..... 1
Changes in Membership..... 26
Changes in Address..... 30

***All correspondence relating to the publication of papers* should be addressed to**

Harry E. Jordan, Secretary
22 East 40th St., New York

$7.00 of Members dues are applied as subscription to the Journal
Additional single copies to members—50 cents
Single copies to non-members—75 cents

Chlorination
CAN HELP STRETCH YOUR TREATMENT CAPACITY

If new housing projects or other wartime needs call for more water than your treatment plant was designed to handle . . . more effective chlorination methods may help you avoid a crisis.

Even without the purchase of additional equipment, some plants have found it possible to employ their W&T Chlorinators to reduce the filter load and supply safe and acceptable water at rates above the normal capacity of the plant. In other cases, Emergency Chlorinators have helped to protect supplies for which permanent treatment equipment was not immediately obtainable.

Distribution systems are being protected by longer-lasting residuals obtained with Chlorine-Ammonia treatment. Breakpoint Chlorination is being employed in other communities, permitting supply sources which were previously considered unavailable to be safely used.

In any case, there's no reason to let safety standards "slack off" as you stretch the capacity of your plant. Your W&T Representative is anxious to help you to employ regular or emergency chlorination so as to get the most out of your present equipment, until such time as a well-balanced treatment plant of adequate capacity can be obtained. He's helping others to meet this kind of crisis . . . why not you? SA 143-S

"The Only Safe Water is a Sterilized Water"

WALLACE & TIERNAN CO., Inc.

MANUFACTURERS OF CHLORINE AND AMMONIA CONTROL APPARATUS
NEWARK, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

JOURNAL
OF THE
AMERICAN WATER WORKS ASSOCIATION

COPYRIGHT, 1943, BY THE AMERICAN WATER WORKS ASSOCIATION

Reproduction of the contents, either as a whole or in part, is forbidden, unless specific permission has been obtained from the Editor of this JOURNAL. The Association is not responsible, as a body, for the facts and opinions advanced in any of the papers or discussions published in its proceedings.

Vol. 35 January 1943 No. 1

War Emphasis in Water Works Management

By Samuel B. Morris

THE red, white and blue "V" on the face of the official program of this wartime conference is emblematic of the hopes, prayers and devotion of our water works membership toward the winning of this war. I wish it also represented a long series of victories already achieved by the United States and its allies. On the field of battle, however, there has been a series of defeats for the allied nations throughout the world for more than three years and for our own country for nearly a year. So far our only real victories have been over our own stupid selves. We have finally been awakened and cemented into a nation fully united in the purpose of defeating the aggressor nations.

Our victory over ourselves has been expressed in our willingness to accept conscription of our able-bodied manpower, from teen-age youths to middle age, to fight on the world's battlefields; our willingness to restrict our consumption of clothing, gasoline, rubber, sugar, meat and other foodstuffs. The acceptance of all of these restrictions and the sacrifice of health and life itself are supported in the belief that we will finally defeat the nations that have brought war and bloodshed upon the principal peoples of the world and that we and our allies will be able to develop a better, safer world in which human needs shall be satisfied and human hopes fostered and protected.

The Long-Time View

Those who are taking a long view of the war are examining the world economic-political-social conditions that caused, or permitted, this devastating conflict. They are looking to the post-war period and trying to conceive a new means of insurance, that peace and goodwill shall exist amongst the peoples of the earth. Some say this is a world revolution, not just a war between powerful nations seeking to establish or protect their modes of life.

A paper presented on October 29, 1942, at the California Section Meeting, Oakland, Calif., by Samuel B. Morris, Vice-Pres., A.W.W.A., Dean, School of Engineering, Stanford Univ., Calif.

They point to one of the few social constants of history—that mankind since the dawn of history has ever been gathering into larger and larger units for his own protection or for conquest, from the family and tribe to the city, state, nation and empire. They see a "World State" arising from the failure of the World Court and the League of Nations as a logical outcome of this great war. The organization of such a World State is not crystallized into a definite plan, but there is the seed in the high hopes of man that his children shall have that safer, better world in which to live.

The Magna Charta, The Bill of Rights, President Wilson's Fourteen Points and the Atlantic Charter have been important steps toward the fulfillment of the hope that mankind is moving toward accomplishment of an earlier utterance of "Peace on earth, good-will to men."

In our ideals and hopes, however, we are made more practical by our failure to win a lasting peace—or any peace at all for that matter—after the World War. Our hopes were high in that day and our national leadership struck the response in human hopes which no American or allied leader has yet done in this war. While grimly fighting this mechanized war in many foreign lands, the people have confidence in the ultimate victory, but our efforts would be much more effective if there were some great spiritual leadership in the allied cause, confident of winning the peace and establishing the dignity and independence of all the people of the earth.

Thus, we look upon the war, and upon the peace to follow, in a very practical, even skeptical, manner. In the reconstruction period there will be no laying down of arms—on our side. The evil leadership of our enemies must, and will, be removed, perhaps "liquidated," to use the expression of our Soviet comrades. My prediction is that, during your lifetime and mine, we will maintain a large, active, policing military force.

Financial Considerations

Debts and taxes, beyond any we have ever conceived, are upon us and will remain. Before the end of the first year of our participation in the war, authorized war expenditures already totaled over 220 billion dollars, three years' total pre-war national income. In our private lives we water works men know how many years it has taken each of us to save three years gross income—or perhaps many of us do not even know yet, if family, education and illnesses have consumed our prospective savings. The war has just begun. How many years it will continue, and at what cost, we cannot foretell.

In Washington, post-war financing and planning are being studied. It is apparent that the large national debt cannot be retired under pre-war depression-year national income. Every effort will be made to provide jobs for every returning soldier and sailor. Only by maintaining a national annual income of 100 billion dollars or more can we expect to provide employment and begin to retire the national debt. The expectation is that a large public works program will be initiated to meet the slack immediately with the coming of peace and partial demobilization. Everywhere industry is also planning the most rapid conversion to peacetime products. All the major manufacturing companies with which I am acquainted have made very thorough studies of this problem and have evolved plans. Water works improve-

ments will be a part of the post-war program.

By necessity and instinct, the water works executive is a planner, a long-time planner, to meet the needs of his community. His has been the task of forecasting trends in population and the needs of water and fire protection years in advance. Come what may, war, peace or depression, his community expects him to have sparkling, clear water in every tap at the correct pressure and free from harmful minerals or water-borne disease.

Facing Present Problems

Turning back the pages of history we find that cities are generally more permanent and stable than states or nations. Water supply and transportation facilities are the physical factors which have sustained the cities through the centuries. Be they public or private, the water works perform to our cities the same important life-sustaining function. It is therefore proper that the long-time planning water works man also take a long-time look at the war and the post-war period. But the current war problems are so pressing that I would not have you overlook the present and the immediate future in taking the long-time view of the war.

General Reybold, Chief of Engineers, tells a story to illustrate this point. It seems that a young engineer, who was working waist-deep in the cold water of a river crossing on the Alaskan Highway, was day-dreaming of his next furlough and of how he would bask in the sun on the beach in a warmer climate. Suddenly he felt a slap on one side and, looking up, he saw a small bear just reaching its paw around his waist. In the ensuing struggle, the young engineer's thoughts were definitely not of basking on a beach during his furlough.

First of all we must meet the immediate needs of war. Our enemies know the military importance of water supply. We must not forget Warsaw, Hongkong and Singapore.

In many California, West Coast, and Mountain State communities, war means great expansion in the industrial demand for water and huge increases in population. This expansion makes necessary new dams, reservoirs, water purification plants, wells, pumping plants, pipelines, distribution mains, services and meters. Your key personnel are reserve officers promptly called to military duty, others volunteer or are drafted. Men and women with years of service leave to accept the higher paid jobs in the flush war industries. You want to keep them but you just cannot meet the salaries paid by industry. By and large the water works employee has been unorganized and poorly paid, but some communities and companies have been a little smarter and more appreciative of the water works man and have paid better salaries, provided better working conditions and sickness and retirement benefits. They are in the best position to meet the present personnel problems; but it is not too late to improve conditions.

Other burdens which have been placed on you are the protection of your water works from sabotage, and the difficulties of operation in dimouts and blackouts. And with your depleted personnel you must assume leadership in various O.C.D. activities. Yes, more than ever before, your community is recognizing the important function the water works man performs. You should help the commu-

nity retain and increase this appreciation of your position.

Obstacles to Action

Although all these problems must be met with key men gone and diminished forces, you feel you could still operate if you had the best equipment and plenty of materials on hand. Anticipating advancing prices and scarcity of materials you bought wisely and went into the war period with above-normal inventories. Confronted with possibilities of sabotage from within and enemy action and air raids from without your first concern has been to provide the materials and equipment which your intimate knowledge of your plant indicated were necessary.

In spite of price ceilings, costs have advanced. Materials are difficult to obtain. You are called a hoarder for your prudent purchases. The War Production Board has ordered you to disgorge your surplus inventory. Your own study indicates you should have all of your inventory to protect your community, and it is likely that you are correct. What if a new industry should come to your system overnight and what if acts of sabotage or enemy action should disable your system. The inventory you had provided would meet these needs. But the War Production Board has a broader knowledge of the problems of supply in relation to the total war needs and we must bow to this higher command.

Each day you receive new priority orders. You discover that the priorities you have been given will not secure the materials and equipment to complete the job. There has been inflation in priority ratings. Other circulars from Washington have to do with labor, manpower, selective service, price control, limitations on housing and services. You cannot get these read in the daytime and you pack your brief case to study them at night. The many changes from day to day and the errors and inconsistencies irritate you. You ask why it is that all this new red tape must be imposed upon you from Washington when you are trying to get more work done in less time with less men, and while new regulations and restrictions are placed in your way to harass you in your work and to delay and negate your best efforts to meet your construction schedule on time. Then you begin to "philosophize" a bit and ask yourself how it is that so much is done in Washington to slow down your work and so much other war work with which you are familiar. Yes it is democracy at work in wartime. Unquestionably much of the machinery for controlling the distribution of labor, material and equipment in which there are shortages will be improved as the war proceeds. You can help these tendencies toward simplification and decentralization.

We must look kindly and sympathetically upon the administration of all of these controls which are being administered in this country for the first time during a state of war. Our totalitarian opponents in this war have had longer experience with these devices of regimentation and control over civilian production and consumption. We realize that we must accept these controls in order to win this war.

The winning of this war is the primary consideration in everything that we do. If for a moment we think some civil program of ours should come first we must stop and ask ourselves what this program would be worth if we should lose this war. And so we must gage everything we do on

one standard—Will it help to win the war?

Most of us are armchair strategists who believe we know how to fight this war better than the General Staff. Unfortunately, underestimation of the enemy and some stupidity in high places caught us off guard on December 7, 1941. But all of us can now see the improvement in our arms and services. We are beginning to take pride in the action of our American boys on the many fronts. And why shouldn't it be so? We who are left behind have seen the best join the services. They are our close friends, our relatives and brothers. For weeks and sometimes months we do not know where those dear to us are—on land, on sea and in the air, whether they are on ice fields, in the deserts or in tropical jungles. Yes, it is a tough and total war.

Whenever we are inclined to complain of our not getting the materials we believe we should have, or when the Selective Service Board decides that one of our key men must bear arms, let us remember how little is our inconvenience and our extra hours of labor in comparison with that of those boys manning tanks on the hot desert sands, trudging through tropical swamps, manning submarines, ships, bombers and fighting planes through our farflung battlefields.

Post-War Water Works Planning

Earlier I mentioned the long-time view of the peace and reconstruction period that are certain to follow the war. Every water works operator should be giving some thought to planning his system for that period. The many uncertainties are challenging. Will the war plants continue to be heavy users? Will the new population remain; will it increase? For every community the answer is different; but the water works operator knows where the weak points in his system are. Many of these he is unable to correct under wartime conditions. He doesn't fret about this situation for he knows that W.P.B. and other higher authorities have decided that the needed materials are more vital to some other part of the war effort. Like a good soldier he begins to absorb some of the obedience to high command that his brothers in military service have had to absorb in the first days of their training.

Let us look practically at this post-war period. I believe it is a fair assumption that there will be an early period of U.S. Government sponsored public works. It is likely that some federal funds will be made available to speed the program. In that day, those water works which have a definite plan and program will be the ones that will receive first consideration. It is truly going to be a very difficult job to get much public work immediately under way that is at the same time soundly planned and economically justified.

Having learned to keep men working during the war period, every effort will be made to keep them working in the post-war period. This should mean greater national income. It is only by keeping everyone at work that the national income can be sustained at a high level. We should not be satisfied with pre-war conditions of service and quality of water. Wherever these are not the best we should determine the feasibility of plans for improvement. Many communities are just beginning to learn the benefits of soft water. Annual fire losses are far greater than they should be. Air-conditioning has

just begun. Treatment of industrial wastes, better sewage disposal and cleaning up of our rivers and harbors should receive concerted action. Comprehensive drainage basin plans have been in the planning stage. A few, such as those on the Colorado River, the Columbia River and the Central Valley Project of California, are well under way and are furnishing water, power, flood control and silt and salinity control of great value during this war. They will develop increasing value during peace.

Manufacturers are going to present water works managers with many lines of improved materials and equipment. The tremendous progress of science, technology and engineering is going to offer great opportunities to the manufacturers. Water works engineers and management must keep abreast of the new developments so that their service to the public will be the best and the most economical.

During the war you are asked to use substitute materials and temporary construction methods that may cost more or have shorter life than the better designs and specifications you have required in peacetime; but when peace does come you will not be returning to pre-war designs. You will have the benefit of new metals, alloys, plastics and chemicals. It will be an interesting and challenging opportunit to improve water works service with such a wide range of new materials and methods as tools in your hands.

It is not a static, drab time in which we are living. Rather it is dynamic, challenging and filled with hope and opportunity for those of vigorous minds and stout hearts. The world stage is set with the most intense rapidly moving drama of all time and the entire audience are participants. The supply and distribution of water is one of t most stable industries, but it is vital to peace and war and to life itself. Water works management willing to make every needed sacrifice stands by our America, facing the future with stern confidence.

Maintenance of Water Supply in Britain Under War Conditions

WATER authorities were called upon to adapt and protect their undertakings against the hazards of modern war with no experience and little knowledge to guide them. It is not surprising, therefore, that all the fears have not been realized and that not all the preparations made have proved adequate. A good deal of experience has now been obtained and it is possible to assess the factors involved much better than when the problems had first to be met.

Generalization is difficult and any suggestions made are not necessarily applicable in all cases. At the present time it is largely an economic problem with some of the factors unknown and it is impossible to calculate exactly the protective measures that are justifiable. Nevertheless, some balance of risks must be decided upon and, in considering operational measures, the gravity of the situation at the time must obviously be taken into account.

Effect of Aerial Attack

The distribution system, including trunk mains within the target area, is the most vulnerable part of any water works system. A considerable part of any urban area is occupied by roads and will receive a proportionate number of hits. The total number of mains broken will be approximately proportional to the total number of H.E. (high explosive) bombs dropped in any given area; and the importance of the main will, in general, vary as the square of the diameter. The number of breaks of each size of main is, within very close limits, proportional to the length of main of each size, laid within the target area. This is of importance in considering the number of pipes of different sizes to be held in stock; one of the factors determining this is the total length of each size of main laid within what is considered the danger area. The number of fractures per unit length of main, due to causes other than enemy action tends to decrease as the main diameter increases, so that stocks of pipes more than, say, 6 in. in diameter will tend to be larger in proportion than normal.

The amount of damage caused by bomb fractures is much greater than that caused by ordinary fractures and the average time taken to repair mains shattered by explosives is about four times the time taken to repair ordinary fractures. The ratio probably increases with pipe diameter and, in exceptional cases, may be very high indeed. In the first place the actual amount of damage is much greater and, secondly, it is

A paper presented to the British Institution of Water Engineers and published anonymously in the November 1942 issue of *Water and Water Engineering* (British); reprinted by permission obtained through the British Information Services, New York.

more difficult to repair. Although the clearing of the crater, if in a road, is the duty of the local authority, it is inadvisable to assume that such a body will necessarily be in a position to undertake this work to suit water main repairs, and it may be necessary for the water authority to clear the crater as well as repair the main. As craters may be of any size up to 100 ft. in diameter and may be full of water and debris, the work involved may be considerable.

The following tabulation gives the approximate length of pipe of different sizes used for repairs as a result of bomb fractures, averaged over a considerable number of incidents:

Diam. of main (*in.*)	3–10	12–15	16–21	24–36	Over 36
Length of pipe used for repair (*yd.*)..	30	25	20	15	10

It has often been found that joints outside the crater need setting up and that occasionally, pipes may be split. This kind of damage is difficult to detect, especially if the main is too small for internal inspection; and in many cases further fractures occur when the main is charged. As might be expected, steel is better in this respect than cast iron. The depth of cover does not greatly affect the damage done, but may make repair more difficult.

Other services than water may be damaged in the same crater and trouble is particularly likely with gas and sewage. Water may penetrate into the gas main and stop the flow of gas. Particular attention should be given to closing valves quickly where important gas mains may also be involved. Sewage may gain access to a damaged water main and cause pollution, but for several reasons this danger has not proved as great as was expected.

Buildings may be destroyed by fire, the services broken and water lost through open ends, resulting in tremendous waste and inability to maintain any pressure in the vicinity. Because of debris or lack of gate valves it may take a very long time to stop all such leaks and, if the destruction is on a large scale, it may be preferable to isolate the whole of the area by closing all valves on the perimeter. If necessary, water must then be relayed for fire fighting through surface pipes.

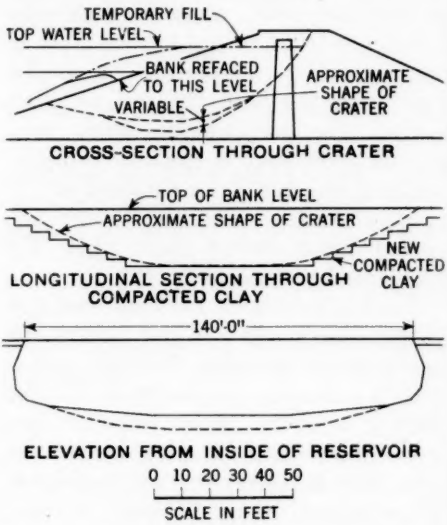

FIG. 1. Details of Large Crater in Reservoir Embankment

Basement shelters have been flooded with heavy loss of life, when nearby water mains in the street have been broken. The water authority is, perhaps, best able to recognize such danger as should be brought to the notice of the shelter authorities.

Fig. 1 gives details of the largest crater yet formed, so far as the author is aware, in a reservoir embankment. The water level at the time was about 9 ft. below T.W.L. (top water level) and as part of the outer bank remained

above T.W.L. no escape of water occurred. Even if the reservoir had been full it is not likely that a breach would have occurred, though the situation would obviously have been more precarious. The bank is composed of a gravelly material.

of the original to provide for erosion. A trench was then sunk through the fill and the compacted clay brought up to the original level. The surface of the fill was then trimmed and refaced, the top of the bank finished off and the reservoir brought back into normal

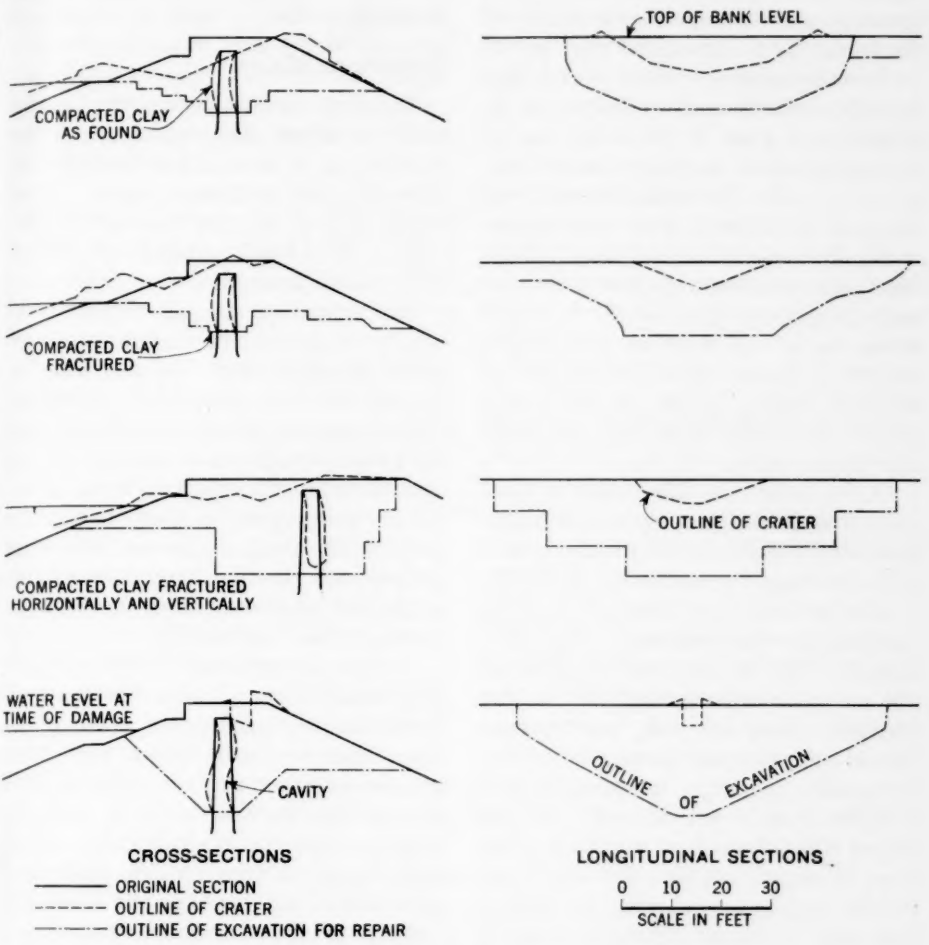

FIG. 2. Typical Craters in Earth Reservoir Embankments

As the water level could not quickly be lowered, temporary repairs were first effected by bulldozing into the crater material obtained from outside the embankment to a profile in excess service. About 4,500 cu.yd. of material had to be replaced.

Examples of other craters are seen in Fig. 2. The effect of H.E. bombs on earthen embankments appears to be

less than might have been expected. It is not much different from the effect of similar bombs upon ordinary ground and is comparatively local. In some cases the compacted clay wall has been displaced or fractured below the actual crater, but not to such an extent as to render it incapable of at least temporarily maintaining the stability of the bank. If a substantial part of the bank remains above water level it will probably stand until repairs can be carried out, even if the core wall is damaged; but if any appreciable flow of water over the embankment took place, it is unlikely that total failure could be avoided. Although these banks are comparatively low, the maximum height being about 40 ft., there seems to be no evidence that height has any influence upon the amount of damage done. None of the cases quoted have been more than ordinarily difficult to repair.

Outlet towers or valves, and in some cases overflows, are very vulnerable. Wherever possible an alternative means of controlling the outflow is desirable.

The liability to damage of pumping stations, service reservoirs and filter stations calls for no special comment. All are vulnerable to direct hit. Filter stations, being of unit construction, should not be put completely out of use except, perhaps, temporarily, and a bypass can be provided if a system cannot function without a service reservoir. Pumping stations driven by electricity supplied from outside sources face the additional risk of loss of power.

Certain key points, such as isolated pumping stations, the head works of upland supplies and long aqueducts, may more easily be damaged by sabotage than by bombing. Perhaps the greatest risk occurs on aqueducts where the pipes are exposed, or at tunnel mouths. It may be argued that the protection of such vital points is the responsibility of the military authorities in the general interest of the community. Events have shown the importance of such works and it is essential that some protection should be afforded.

Repairs to Mains

The first question to be settled is the order in which the repairs are to be carried out, so as to achieve maximum effect in the minimum time. This order cannot be decided before the event, as it will depend on which works are damaged.

The second question is whether temporary or permanent repairs are to be made in each case. In the case of large mains, say, over 12 in. diameter, it is usually preferable to make permanent repairs unless this cannot be done immediately. Temporary repairs involve cutting into the main beyond the crater and, being major operations in themselves, do not save much time, while the total amount of work to be done is much increased.

Temporary repairs are more suitable for smaller pipes. Various proprietary devices are available for closing the open end of small pipes and have proved satisfactory. If fitted with a special cap, hose connections may be used to 'join' the broken ends. Such repairs can be very quickly made and are useful for rapidly restoring the supply to areas supplied through a single main. Any such special apparatus should be standardized wherever possible. Temporary connections need not be of the full diameter, but should be flexible and standardized as far as possible. A main fed from both directions may be capped at each side

of the crater until permanent repairs are feasible.

Many patent joints are now available, the principal advantages claimed for them being the saving of time and skill, together with their flexibility. These are desirable advantages because skilled jointers are likely to be very scarce and, even if concrete support is given to a main, it is desirable that the joints should provide for slight ground movements. Such joints combined with steel pipes probably form the best method of repair to mains in bomb craters. Nevertheless, the majority of such repairs have so far been made with lead joints and steel or cast-iron pipes and it is remarkable what little trouble due to settlement has so far been experienced.

Tests have been made to find efficient substitutes for lead and rubber in case these jointing materials become difficult to obtain. Materials tested in socket joints include cement mixtures, asphalt mixtures, proprietary materials and wooden wedges. The most successful proved to be a mixture, by volume, of one part rapid-hardening cement, three parts clean sand and four parts wood borings obtained from yellow deal with a 1-in. auger. In making this point it is important that the socket be tightly yarned first to make a firm bed. Using a minimum of water, a layer of cement and sand compo is tamped into the socket and wood borings then pressed into the compo. This is followed by alternate layers of compo and borings to within ½ in. of the face of the joint, which is then completed with mortar only, the whole joint being calked with a hand hammer. A 12-in. joint made in this way will stand a test pressure of 300 ft. within three hours of completion. On one occasion a 4-in. joint withstood a pressure of 500 psi. half an hour after completion. Joints larger than 12 in. may require a longer setting time, but there seems to be no other reason why they should not be satisfactory up to a reasonable diameter.

Square hemp hydraulic packing has been found suitable for flexible couplings of the Johnson, Stanton and Staveley types. For flange joints many substitutions have proved suitable. These include paper of various kinds, flannel and burlap. Flanges and jointing material should first be painted with bituminous paint.

Compressors and mobile cranes are needed much more than usual to clear craters, break up additional road surface and handle pipes in situations where the usual shear legs cannot easily be used.

Repairs to Other Works

Mobile track-laying machinery of modern design is very suitable for the repair of damage to embankments if on a large scale. It can work in confined situations, in bad ground or on steep slopes and has a high rate of output. For smaller jobs, manual labor is economical and more suitable. A good deal of preliminary excavation to solid ground may be necessary. Special precautions must be taken to secure proper consolidation when refilling, in order to bond the new work with the old. If this is done, very little settlement will take place. In some cases it has been of the order of 1 in. during the first year after repair. The compacted clay wall is usually replaced at the same time as the bank material, but if machinery is used it may be preferable to refill the whole excavation with bank filling and then excavating a trench to replace the puddle. It would be prudent to make a prelim-

inary search near each dam to find out where suitable materials can be obtained for repairs.

There is no doubt that reinforced concrete stands up extremely well against high explosives, with only local damage, but brickwork suffers more severely, especially if of multi-storied construction. A number of brick service reservoirs constructed with arched roofs have been hit, but in no case has such a roof collapsed, the severe damage being localized, with minor damage such as cracks extending further. In repairing filters and service reservoirs the best solution is often to construct new elements such as walls or columns, inside or around the old ones. Holes in reservoir roofs may be covered with a light frame and repairs left until a later date. In all cases the damaged structure should be examined at the earliest opportunity to determine the full extent of the damage.

Remedial Measures and Protection of Pipelines

The justifiable protection of any undertaking is a very difficult matter to assess and is governed by several factors, among them being: present conditions, the importance of the supply, the probability of damage and alternative supplies. It is obviously uneconomic for each undertaking to be completely safeguarded against war damage out of its own resources of labor and plant. At the same time, every undertaking should be able to draw on sufficient reserves to meet any anticipated contingency. It is therefore urged that major measures for the protection of works should be organized on a regional basis. Much has already been achieved along these lines and its value demonstrated. In considering regional schemes the type of undertaking should be considered as well as its geographical position.

Such an authority would deal with the formation of a common water policy, the provision and use of emergency plant and the standardization of equipment throughout the region. Policy could be dealt with by a committee of representatives and technical matters by suitable subcommittees, but the administration of the region should be vested in a regional engineer, with all necessary powers and full control of the resources of the region. A reporting center would be necessary and the regional engineer should be supplied with skeleton diagrams of each area showing the area of supply, trunk mains, zones, pumping stations and reservoirs.

In some parts of the country it would be a simple matter to connect the mains of adjacent undertakings along the boundaries of supply. Such connections would usually be of small diameter but the quantity capable of passing through the connection could easily be increased by boosting with pumps of the trailer type.

Inter-connections between the trunk mains of different pressure zones of the same authority have proved invaluable and should be made wherever possible. These inter-connections may also be adopted for emergency boosting purposes.

A great shortage of skilled pipelayers and jointers is likely if the distribution system is severely damaged. This is a strong argument in favor of mechanical joints, but, unless reliance is placed on these, unskilled personnel should be trained in jointing. At one works a pipe-jointing school has been established, where laborers have been trained in from three to five weeks to make joints up to 24 in. in diameter.

Instruction is given in making and cutting out lead joints, pipe cutting, making flange joints, flexible joints, packing valves and testing. One instructor can handle eight trainees and it is found advisable in some cases to give some preliminary instruction followed by a further course at a later date. On return to normal duty the men are given sufficient practice to enable them to retain the skill they have acquired.

Protection of Other Works

The protection of reservoir embankments is a matter of great difficulty. The only really feasible method is to lower the water level, which entails loss of storage and a reduced yield in dry years. The effect of this will vary in each case, but it is important to remember that the full storage capacity is only required in exceptionally dry years and the storage remaining would be sufficient to meet normal requirements.

For earth embankments of the usual profile a very considerable degree of protection can be obtained by even a modest reduction in water level; and experience suggests that 5 ft. is a reasonable figure to adopt. The reduction in level may be varied throughout the year, being made greatest in early winter and least in spring, when maximum storage is required. In this way the benefit of a considerable reduction in depth may be obtained over the greater part of the year, with less than the corresponding risk.

The only other practicable precaution which can be taken is to adopt some form of camouflage designed to break up the straight lines which characterize dams, especially the water line. This would make it difficult to determine the exact position of the dam with the accuracy needed to cause severe damage.

Pumping stations may be camouflaged and protected against blast and splinters. Large units are not likely to be fractured by splinters, but auxiliaries may be. Complete box or tunnel shelters may be built around such vital points as well heads and turbine units, which would, in addition to protecting the machinery, help to maintain the morale of the personnel. Concrete or 14-in. brickwork may be used, but both need to be reinforced and the roof must be tied into the walls. Engine room floors may need supporting before shelters can be built on them. A certain amount of emergency pumping plant may be justifiable, but since the probability of needing it is small, the machinery should be mobile and provided on a regional basis. Suitable connections to suction and delivery mains should be provided at each pumping station.

Bypasses to service reservoirs, contact tanks or filters will enable the supply to be maintained if these elements are put out of action.

Rationing of Supplies

Circumstances may arise to make it essential to reduce consumption in a given area to a fraction of that normally used, the difficulty being to secure uniform distribution. As voluntary efforts are not likely to prove sufficient, some form of rationing may become necessary.

The inherent difficulties in rationing water are very great. Control must normally be exercised on the distribution mains, since trunk main pressures should be maintained while consumption is reduced. One method is to reduce the number of feeds off trunk mains or to supply through "cracked

valves," keeping all distributing mains full, so as to force water to greater distances or higher levels.

Another and more positive method is to cut off certain streets altogether, a good arrangement being to isolate alternate streets. Consumers thus cut off would obtain supplies either from those premises remaining on supply or from hydrants on the live mains. Although such a scheme would necessitate closing many valves, most of them could be permanently closed so that the number to be operated in an emergency would be reduced to a minimum. The closed valves could then be opened at intervals as a routine measure to maintain some circulation. The labor required to operate the scheme might be considerable, but the immediate effect would be commensurate with the effort. It would assist in the employment of additional labor if valve boxes were suitably marked.

There are some dangers in such a course, but on balance the total risk is reduced. It may be noted that orders have already been made in some cases allowing water undertakings to suspend their statutory obligations in an emergency.

Alternative Sources of Supply

Much attention is now being given to alternative sources of supply to be brought into use if existing supplies are cut off or inadequate. Usually these will consist of either privately owned wells or surface streams and should be situated as near as possible to the area of supply.

Search should first be made for suitable wells within or near the area of supply, as these sources will probably only need chlorinating. In examining the site, the selection of the sample should be carefully made and the installation itself examined, since many cases have been found where water, initially pure, becomes polluted in the storage tank or in cross-connections.

Surface water supplies require more elaborate treatment and handling. Pumping will usually be required and a hydraulic ram may be useful in some cases. Springs are preferable to streams, as chlorination would then be a sufficient treatment, whereas streams or rivers may require some form of clarification. A small lake or pond, which might be useful as a sedimentation or contact basin, is often to be found. In general, each supply will require some special permanent adaptation, but equipment such as pumps and chlorinating apparatus should be mobile.

Refined treatment of emergency supplies is undesirable; and whatever treatment is adopted should be simple, quick and effective. Each potential emergency supply should be examined bacteriologically at regular intervals, say, monthly. This record will be of great value if pollution is at any time suspected. If the history is satisfactory, a precautionary dose of chlorine may be administered, otherwise the water must be super-chlorinated and de-chlorinated.

Water from emergency sources will usually have to be transported to the distribution area by mobile tanks, which can then be used for chlorinating purposes. This involves more supervision and, as this is likely to be already difficult, a single treatment point is to be preferred. If the supply is conveniently situated in or near the distribution area, arrangements may be made to supply the public direct, to save transport. In certain cases it may be possible to obtain an emergency

supply from a stream at the point where it crosses an aqueduct which has been put out of order. The supply could then be pumped into the aqueduct for transmission to the distribution area.

Emergency Distribution of Water

The distribution of emergency supplies presents some difficulties, which increase with the size of the undertaking. The difficulties are caused by the large numbers of vehicles and personnel required, the absence of any skeleton organization in the normal system, the strangeness of the work and the speed with which it has to be brought into operation.

Distribution can be carried out by one of three methods. Firstly, a certain area can be allocated to each vehicle with orders to patrol the streets in that area. Another method is to direct the tanks to certain fixed points only, the consumer to fetch water from those points. The third method is to erect stationary tanks to be filled by mobile tanks. The best method depends largely on the number of tanks and/or vehicles available.

The first method is convenient for most consumers, but inefficient in transport. Guides are necessary to direct strange drivers, and they are difficult to obtain. Moreover, it is difficult to prevent overlapping of routes. It is, however, a convenient method in case of local failure when only a small area is affected. The second method has many points in its favor. Suitable points off main roads can be chosen and clearly marked in advance, so that the public may become familiar with the places at which water may be obtained. No guides are necessary. Transport is used much more efficiently and the amount of water sent into a given area can easily be varied. The organization is flexible, much simpler, and more easily controlled than in the first method. The crux of this method is that the public must know where water can be obtained. It would be an advantage if a man could be stationed at each distributing point, but this is not essential. The third method is the most efficient in transport, and this is important, as transport is likely to be the weakest link in any emergency distribution scheme. The method is uneconomical in tanks but, if the necessary tanks and equipment can be obtained, will provide the greatest measure of security. The capital cost is greatest, but the saving in transport charges would balance the additional capital cost after only about five days operation. The stationary tanks should be permanently erected, preferably in close proximity to wardens' posts, if arrangements can be made for the wardens to take charge of the tanks.

If provision has to be made for an emergency supply to the whole area, for example, as a precaution against invasion, distribution by stationary tanks is likely to be the most satisfactory method and the easiest to operate. If provision has to be made for only a partial failure, as for ordinary "blitz" conditions, especially if regional assistance may be expected, the second method may be sufficient.

Suitable tanks for carrying on trucks are of 500 to 600 gal. capacity, fitted with baffles and a large hinged filling inlet, and of 12 gage galvanized steel. Good quality fullway plug cocks are desirable for rapid delivery. Three such cocks, 1 in. in diameter with 3 ft. 6 in. of 1-in. diameter hose attached, will empty 500 gal. of water from a tank in 15 min. If the mobile tanks

are to be used for filling stationary tanks, they should be fitted with a large-diameter emptying pipe and valve. A rigid hose or pipe is preferable, as canvas fire hose becomes flattened in storage and creates excessive friction.

Stationary tanks of pre-cast concrete are usually cheaper and easier to obtain than steel tanks. Sectional tanks bolted together, with the joints run with bitumen, have proved satisfactory. In designing and fixing stationary tanks, the difficulty of filling them from mobile tanks without pumping should be kept in mind. Advantage can sometimes be taken of sloping ground to obtain extra head.

To calculate the number of tanks required, it is usual to assume that each person requires 1 gpd. Using the first method, vehicles average about three trips per day, i.e., each vehicle will serve about 1,500 people. If distribution is by the second method, this number could probably be increased by 50 to 100 per cent. If stationary tanks are used, the mobile tanks may make 8 to 10 trips per day. These figures assume an average round trip of not more than 8 mi. and a 12-hr. working day. Stationary tanks should be sited about ½ mi. apart and mobile tanks filled only at fixed points where proper arrangements can be made and from which strict control over distribution can be maintained.

If transport cannot be provided by the water authority, arrangements should be made with the local representative of the Regional Transport Commissioner for the use of suitable vehicles, which can then be scheduled and reserved for this purpose. A generous margin of trucks should be provided, since not all of them may be available when required. Particulars should also be obtained of local tank vehicles of all descriptions, most of which can easily be made suitable for distributing water either by chlorination or steaming. The latter can be carried out by inserting a steam pipe in the top of a tank truck,* packing with waste and draining the condensate through the outlet cocks.

Supplies for Fire Fighting

The ordinary distribution system is designed for domestic supply and is incapable of supplying the amount of water needed for extinguishing fires caused by heavy air raids. In any case, the great length of mains renders such a system very vulnerable. Many sources of supply, such as, rivers, canals and docks, are available for fire purposes which would not be considered suitable for domestic supply. These resources and storage tanks should be developed to the utmost in addition to the public supply.

Water Works A.R.P. Control

The functions of a water works A.R.P. control organization are to receive information regarding damage to the water works, analyze the reports, and take the necessary action. The organization must suit local conditions, i.e., the existing water works organization, civil defense and fire service. Over 90 per cent of reports received during air raids are from the civil defense authority; therefore, the water works control and civil defense must be closely related. The degree of

* The U.S. Office of Civilian Defense has issued instructions for de-contamination of tank trucks. Reference should be made to these documents, obtainable through the State Water Co-ordinators.

centralization is the chief problem to be decided. If the water authority covers a number of civil defense areas, incidents should be reported direct to local depots or service men. Civil defense authorities should be supplied with plans showing exact details of the water control boundaries. The advantage of direct reporting to local depots is the increased reliability of the communications, the saving of time and increased accuracy.

A central reporting center is, however, necessary in every case. Other depots are primarily intended as local reporting centers and for dealing directly with minor matters, such as shutting off broken mains. The central control should deal with reports of major damage, matters affecting more than one district, other authorities and outside assistance. It could act as an alternative to the local reporting centers. The staff should consist of a responsible engineer, telephone operator and assistants to deal with messages.

Service men should be on continuous standby duty, either at home or a depot, to isolate damaged mains. Many more are required than for peacetime operation; in fact, it would be difficult to have too many during a heavy raid. An approximate estimate of the number required is about 1 per 10,000 of the population.

It is undesirable to keep repair gangs continuously on duty. What is much more important is to have large resources available which can be drawn upon within a reasonable time. Only in the most extreme circumstances is continuous working justified and unless plant is the limiting factor, the maximum output is likely to be attained with a single shift of moderate length. After a certain time, excessive hours do not increase output.

Relations With Consumers

There is much need for improvement in the relations between water authorities and consumers, especially under war conditions, in the means of disseminating information during an emergency. Advertising may be used for matters of a general nature, but it is insufficient for dealing with emergency conditions. A medium is required which is in close contact with the local public and capable of independent action.

The wardens' organization created by the civil defense authorities is built up in such a way as to form an admirable service with which such an organization could be linked. The suggestion is that in each district a "water warden" should be appointed to act as liaison between the water authority and the public. This person would form an integral part of the civil defense service, preferably a full-time member, and should at all times be readily available within his district. The duties of water wardens would be:

1. To act as liaison officers between the water authority and the public and to distribute information regarding the water situation
2. To inform the public when and how to reduce consumption to an emergency level of 1 to 2 gpd. per head
3. To inform the public where emergency supplies can be obtained
4. To assist in obtaining and distributing such emergency supplies if necessary
5. To advise the public how to sterilize water
6. To assist, if requested, to operate valves
7. In suitable areas to assume local

responsibility for water supply if his district is isolated during an invasion.

Except in special cases it is not advisable to allow water wardens to interfere with mains or apparatus except to fix hydrants. Water wardens would need special training by the water authority in the above duties. When fully trained they could instruct post wardens in duties (2), (3), (4) and (5), who would then be in a position to contact the public when necessary. Booklets for the use of wardens and handbills for the public would need to be prepared. It is not suggested that this system of water wardens should in any way relieve the water authority of any part of its responsibility, but it should provide a link whereby the civil defense organization could assist the water authority to carry out its obligations and so maintain the life and morale of the community. Such a system would have many advantages. Advice and information would be available locally, when it was needed, in small units, which would be self-sufficient in water supply so far as this was possible. These units would in themselves be adaptable to integration into larger units, being based on a larger organization, itself composed of such units. The training given could be much more thorough than could be given to the public and information could be transmitted quickly and easily to the water wardens through the civil defense control center.

Can American Water Systems Provide for Civilian Defense

By Kenneth J. Carl

SINCE the severe bombardments of English cities during the 1941 "blitz," many papers have been written in this country concerning water supply operations during periods of national emergency. These papers have dealt chiefly with the protection of water supply systems from injury as a result of sabotage or direct attack and have been based in a large degree upon reports received from England. Little, if any, attempt has been made to evaluate the characteristics by which American water supply systems differ from those of Europe, with respect to their relative abilities to provide for civilian defense. Perhaps this has been due to the general lack of data upon which such an evaluation could be made. In the files of the National Board of Fire Underwriters (N.B.F.U.) are detailed studies and reports on the water supply systems of over 450 cities with populations of 25,000 and over. From an examination of some of these data and from information available on the water supply systems of Europe, and particularly England, the author has, in this paper sought to determine whether or not American systems can provide for civilian defense.

A paper by Kenneth J. Carl, Field Engr., The National Board of Fire Underwriters, Com. on Fire Prevention and Eng. Stds.; presented on October 15, 1942, at the New York Section Meeting, Albany, N.Y., and on October 20, 1942, at the Kentucky-Tennessee Section Meeting, Paducah, Ky.

Adequacy in Design

In the first place, in the examination of English systems, it becomes evident that, as a general rule, fire protection has not been stressed in the original design or in subsequent improvement programs, with perhaps the exception of those projects which have been undertaken as a direct result of the war, and concerning which little is known. This fact is brought out by the following statement of John Bowman, City Water Engineer of Edinburgh, Scotland, and President of the Institution of Water Engineers (1):

"Generally it may be said that the main pipes in most towns are not adequate, except in the main streets, to supply water for fire extinguishing purposes."

In our country the problem of providing enough water for fire protection in addition to the demands of consumption is one that is given important consideration by all consulting and operating water supply engineers. The N.B.F.U. "Standard Grading Schedule" (2) has been developed over a long period of years for the purpose of classifying our cities on the basis of their fire defenses and physical conditions. That portion of it which deals with water supply sets certain stand-

ards which have been generally accepted as good practice by engineers throughout the country. By making improvements in accordance with the principles outlined in this schedule, many cities now possess systems adequate for domestic and general fire use, and with a considerable degree of reliability in the event of emergencies. As a result of this greater emphasis on fire protection, it can be said that American systems should generally be better able to cope with the requirements of civilian defense in wartime than those of England.

It is a well accepted fact that water consumption per capita in the United States is greater than in Europe. It can easily be seen that during and immediately after an air raid, domestic consumption would be low, leaving a greater portion of the capacity of the mains for civilian defense and fire department use. It then follows that, in this country, where the mains are designed for larger consumption, the additional capacity available for emergency use will be greater than in Europe, where the mains are designed for low consumption.

Damage to Works

From the experience of the English, it appears that little, if any, damage has been inflicted by the enemy on reservoir dams, pumping stations or other structures of the supply works. Whether this is due to a plan of enemy action or their inability to hit these structures is not known. Harry E. Jordan (3), Secretary of the American Water Works Association, throws some light on the situation when he states:

"Overseas experience has indicated that well organized antiaircraft defense can keep enemy planes flying so high that definite objectives in the defended area cannot easily be hit. In such case, air bombing becomes a random operation, and hits upon certain types of structures, such as pumping stations, filters and mains become a matter of simple area-probability."

William W. Brush (4), Editor of *Water Works Engineering* has written the following concerning the damage caused by air attacks:

"The damage may come from chance hits, with mains suffering most because they occupy so much more of the attacked area than other vulnerable parts of the water system. While duplication and protection of essential parts of the supply system are desirable, the reports from England indicate that interference with water supply at the source and on its way to the distribution system has not been an important item in the water purveyor's problems."

It is therefore reasonable to assume that if bombings should occur on a large scale in this country, the damage that may be done to supply works would be slight, but distribution mains which are spread over wide areas would undoubtedly be damaged at various points. It is stated that, with reasonably effective air defense, the breaks in water mains may develop at the rate of one per hundred miles of mains per day (3).

Extinguishing Incendiary Fires

During most air attacks, small incendiary bombs, about which we all have heard a great deal, are dropped by the enemy in an attempt to start fires simultaneously in many places to cause confusion among the population and civil authorities, to destroy objectives by fire and to improve the visibility of targets. Because of the multi-

plicity of these small fires, the extinguishment of most of them has been assigned to the local air raid wardens and householders.

Until recently most literature and discussions on incendiary bombs have dealt with effective means of extinguishing the bomb itself, and little has been said about the fires started by the bombs in combustible material. During the first two minutes after striking, the thermite in the common type of incendiary bomb burns violently, throwing bits of molten metal for considerable distances. If such a bomb has landed in a house, the upholstered furniture, curtains, woodwork and other combustible materials ordinarily found in most homes would immediately be set on fire. It is now known that there are many types of incendiary bombs and that new types may be expected in the future. Regardless of the type of bomb employed by the enemy, it is certain that small fires will be started in combustible materials, and that these fires must be quickly extinguished.

To extinguish fires involving the ordinary combustible materials found in most houses, the most effective agency is water. Sand or the other compounds which have been developed for the extinguishment of incendiary bombs cannot be used very effectively on a blazing curtain or upholstered chair. The problem then is the most effective means of applying water to these fires in the home, remembering that in some cases it will have to be applied by women or children. In England the widespread use of the stirrup pump is well known to all. In addition to this, hand fire extinguishers and hand pump tanks have been recommended. At present we know that it is practically impossible to supply each home with any one of these appliances. Practically every home in the country has some garden hose and, if it has not, it can still be purchased in most localities. If suitable outlets for the use of this hose can be provided within the house, with an ordinary garden nozzle, there is available an inexpensive and effective means of extinguishing the bombs and the fires which they start. Faucets can be provided with garden hose screw threads and numerous patented adapters are available at a nominal cost for use on ordinary faucets.

The effective use of this hose depends upon the availability of water at suitable pressures during a bombing attack in which some injury to the distribution system may be sustained. If a main were broken during an air raid, the water department would naturally take steps to shut it down as quickly as possible. Some time would then elapse before the crew could be dispatched to the scene and the valves to be closed designated and located. In some departments this time might be very short but in others, where emergency crews were not well organized and valve records were poor, it might be excessive. With a break of this type, the flow from each broken end would be considerable and, if the main were large, the difficulties of shutting down are evident. Assuming that the mains were designed and valved so that, after the shut-off was made, adequate quantities and pressures would still be available, it can be seen that enough time would elapse, between the time of the break and the shut-off, for small fires started by incendiary bombs to spread considerably unless properly extinguished. It is important, then, to determine whether or not water systems can deliver ade-

TABLE 1

Available Fire Flows in 50 U.S. Cities as Indicated by N.B.F.U. Tests

No.	Population	Fire Flow in Gallons per Minute Available at Residual Pressure of 20 psi.		
		Principal Mercantile District	Manufacturing Districts	Residential Districts
1	100,000	20,000	2,200–10,600	1,500– 7,700
2	101,000	13,000	3,400– 5,200	900– 6,200
3	101,000	14,900	1,500– 7,500	1,200– 5,800
4	105,000	14,200	4,000– 9,000	2,000–10,000
5	112,000	13,500	1,500– 6,300	1,300– 5,100
6	112,000	16,000	2,300	800–11,600
7	112,000	22,100	1,000– 3,500	900– 6,700
8	115,000	9,500	2,500– 6,000	1,800–11,400
9	115,000	15,000	2,000–11,000	4,000– 7,000
10	116,000	14,200	4,700– 9,200	1,700– 7,900
11	118,000	8,000	1,500– 6,300	1,100– 3,800
12	121,000	6,100	1,300– 8,100	1,000– 2,400
13	124,000	11,000	1,000– 5,800	800– 4,800
14	135,000	15,100	2,500–11,600	1,700–14,000
15	135,000	13,500	10,100	900– 5,900
16	142,000	17,600	—	600– 5,000
17	147,000	10,500	6,600	2,800– 8,700
18	153,000	12,800	2,900	700– 4,300
19	155,000	24,300	2,650– 9,150	700– 6,600
20	160,000	32,000	1,500– 7,500	900– 7,000
21	160,000	12,900	2,500–12,000	1,500–10,200
22	180,000	11,300	3,000– 5,000	1,000– 7,000
23	186,000	10,400	3,400– 3,700	700– 4,500
24	200,000	22,600	15,400	900– 4,600
25	211,000	23,100	1,000–10,400	1,500–10,200
26	220,000	19,200	1,100– 6,000	800– 3,700
27	225,000	26,000	9,000–14,000	1,600–14,000
28	250,000	20,300	1,600–10,200	1,100– 7,300
29	270,000	15,400	1,400– 8,800	900– 4,600
30	275,000	7,400	2,700–13,900	1,300– 6,850
31	275,000	26,000	1,500– 5,000	1,000– 5,000
32	288,000	16,000	2,500–16,600	800– 7,400
33	300,000	28,400	1,600–17,000	1,200–17,800
34	300,000	19,000	2,300– 5,600	1,300– 6,300
35	300,000	18,500	1,500– 5,200	1,300–13,000
36	310,000	24,200	2,500– 7,000	1,500– 5,000
37	319,000	23,400	2,600–12,400	1,600– 9,400
38	329,000	25,000	4,000–11,700	1,900– 9,200
39	330,000	16,900	600–10,800	1,600– 7,550
40	370,000	33,600	2,200–10,600	900–11,900
41	395,000	59,000	6,000–20,500	1,100–19,200
42	450,000	10,300	2,800– 7,500	2,100–10,000
43	466,000	23,500	2,000–17,300	1,300– 7,000
44	492,000	28,300	3,000–10,000	2,000– 6,000
45	580,000	23,000	5,200–19,000	1,800– 5,100
46	610,000	17,000	6,800–19,000	900– 9,000
47	663,000	12,200	4,600	900– 7,600
48	800,000	39,000	5,000–17,000	Over 4,000
49	1,400,000	26,500	2,500–15,700	1,200–16,300
50	1,555,000	25,000	1,300–15,600	1,500–15,200

quate quantities in most areas to provide small streams at suitable pressures during the time that a large flow may be gushing from both ends of a broken main.

Adequacy of Supplies

From experiments made with an ordinary garden nozzle attached to 50 ft. of ¾-in. garden hose, it was found that a satisfactory stream of 3.5 gpm., which would carry for distances up to 20 ft., could be obtained with a nozzle pressure of about 9 psi. This pressure should be available about 3 ft. above the attic floor or in the average 2½-story dwelling about 25 ft. above the street. Experiments recently made by Underwriters' Laboratories, Inc. (5), with 50-ft. lengths of ¾-in. garden hose show that, for a flow of 3.5 gpm., the loss of head is 2 ft. If it is assumed that the average length of service and house pipe to the outlet in use is 100 ft. and that the average size is ¾-in., the loss will be about 5 ft. Adding these losses and the pressure required at the nozzle, it is found that a total pressure of about 23 psi. is necessary at street level.

On the basis of this requirement, cities in various parts of the country were selected and studies made based upon data in the files obtained on recent N.B.F.U. surveys. A main near a point where a previous fire flow test had been made was selected and considered broken. First the flows from the broken ends were estimated, assuming them in most cases to be equal; then, by the "trial and error" method, a total flow which would agree hydraulically with the conditions indicated by the test was obtained. The loss of head per 100 ft. was then computed for the given flow and, using this slope, it was possible to determine just how far away from the break the pressure would be 23 psi. Since the fire flow tests made by the N.B.F.U. are located to give a representative analysis of the strength of the distribution systems, it follows that any studies based on them should also indicate representative conditions.

In general it was found that breaks in 6- or 8-in. mains, in areas where the gridiron and initial pressures are fair to good, would only reduce pressures below those required for small streams in a small area within a radius of about 500 ft. On larger mains, the areas affected were naturally more extensive. In one New England and two western cities breaks in 12-in. mains and in 3 southern cities breaks in 16-in. mains would adversely affect areas only within a radius of 1,000 ft. or less.

Tables 1 and 2 will give a quick general verification of these statements. Table 1 indicates the quantities of water generally available at a residual pressure of 20 psi. as determined in 50 cities of 100,000 or greater population, selected at random. The maximum amounts are given for the principal mercantile districts. Table 2 shows the discharges from the ends of pipes of various sizes for velocity pressures of 1, 5 and 10 psi. and the friction losses produced in the pipe by the flows to the open ends. A study of Table 1 will show that, in the principal mercantile districts, quantities of from 6,100 to 59,000 gpm. could flow from a break without reducing the pressure below 20 psi. In other words, with flows of these magnitudes, there would be practically sufficient pressure at the break to furnish the supply for small hose streams. If the flows were greater and reduced the residual pressure below 10 psi., it can be determined from

TABLE 2

Discharges (Coef. = 0.70) From Ends of Pipes of Various Sizes for Several Velocity Pressures and Corresponding Friction Losses (C = 100) in Pipes per 100 Feet of Pipe

Pipe Size	Velocity Pressure = 1 lb.		Velocity Pressure = 5 lb.		Velocity Pressure = 10 lb.	
	Discharge	Friction Loss	Discharge	Friction Loss	Discharge	Friction Loss
in.	*gpm.*	*psi.*	*gpm.*	*psi.*	*gpm.*	*psi.*
6	750	2.6	1,700	13.2	2,400	26.0
8	1,350	2.3	3,000	8.8	4,250	18.2
10	2,100	1.7	4,700	7.6	6,600	15.6
12	3,000	1.4	6,700	6.1	9,500	11.6
16	5,350	1.0	11,900	4.3	16,900	8.2
18	6,750	0.9	15,100	3.8	21,400	7.2
20	8,350	0.7	18,700	3.4	26,400	6.3
24	12,000	0.6	26,900	2.7	38,000	5.2

*For a pipe ruptured, with two ends flowing, the discharge may be double the above quantities.

TABLE 3

Average Length of Gate Valve Shut-off Sections in 50 U.S. Cities as Indicated in N.B.F.U. Reports

No.	High Value Districts	Residential Districts	On Large Mains	No.	High Value Districts	Residential Districts	On Large Mains
	ft.	*ft.*	*ft.*		*ft.*	*ft.*	*ft.*
1	480	660		26	770	1520	
2	700	830		27	525	750	1000
3	540	860		28	485	780	
4	380	355	525	29	900	1380	
5	505	870		30	640	730	
6	720	1550		31	650	770	1510
7	350	540		32	570	1240	2000
8	960	910		33	580	1120	
9	500	480		34	670	1530	750
10	470	605		35	635	1550	
11	550	500		36	560	1030	
12	1120	1715		37	555	770	
13	980	700	900	38	630	870	1730
14	490	760	1400	39	650	870	
15	550	1150	1700	40	700	1330	
16	880	1130	2000	41	440	885	1550
17	700	800	1900	42	490	610	
18	500	950	1235	43	480	800	
19	680	625		44	540	1080	
20	540	1080		45	530	450	
21	460	900	1300	46	315	465	
22	880	990	1760	47	450	480	
23	655	975		48	460	490	1000
24	670	1400		49	730	990	2500
25	550	785	2000	50	650	700	

Table 2 just how far from the break a satisfactory pressure would exist. For instance, in the case of city No. 9, with a population of 275,000, where a flow of 26,000 gpm. was available at 20 psi.; if more hydrants had been opened and the pressure reduced to 5 psi., a greater quantity, say 30,000 gpm., would be discharged. This could be assumed as 15,000 from each end of a broken pipe. This is about what would obtain from a main 18 in. in size. Using Table 2 it will be found that the required pressure for small hose streams under these conditions will be available at $\frac{23-5}{3.8} \times 100 = 475$ ft. up the main from the break.

It is known, of course, that there will be places in any system where this will not hold true, but the fact that it is true in many places indicates that these systems are in general well equipped to provide for civilian defense. Another point to bear in mind is the fact that the greater part of U.S. systems are made up of 6- and 8-in. pipe on which the effects of breaks will be less severe. It should be pointed out that, if a break occurs at a low point in a city, the high areas will naturally be affected, but that, in most cities, there are separate services for the high areas, with separate distributing storage. Hence, on these high services, a practically, normal supply would be available.

Adequacy of Valves and Hydrants

All reports from England point out the necessity of an adequate number of well distributed gate valves to make shut-off lengths as short as possible. Most American systems are much better equipped with gate valves than those in other countries. Many of them have installed their valves in accordance with the requirements of the N.B.F.U., which call for shut-off sections not in excess of 500 ft. in high value districts or 800 ft. in residential districts. Table 3 shows the average shut-off lengths for the 50 cities indicated in Table 1. An examination of this table will show that, in most cases, the shut-off lengths are such that relatively small sections of the distribution system will be affected by a break.

The speed with which a shut-off can be effected is of considerable importance in operations during an attack. Generally, with all other factors equal, it will depend upon the number of valves to be closed. Three representative cities were selected and a study made of the shut-off lengths in the principal mercantile districts. Of 142 lengths, 68 could be effected by operating 2 valves; 30, by 3 valves; and 31, by 4 valves; the remaining 14 lengths required from 5 to 8 valves. Thus, it can be seen that, in most cases, it is only necessary to operate a few valves to shut off sections of mains which may be damaged; and the resultant speed of these operations not only aids in maintaining a more satisfactory supply for fire fighting in the city, but also enables the water department to accomplish more work with a given force of men.

Hydrant size and distribution are other factors which are important in defense against the large fires which are usually started during most air attacks. In England many of the hydrants in service are much too small, while, in this country, most cities have hydrants of adequate size, well designed for fire service. It has been proved by experience that hydrant installations should be made on the basis of the area served rather than the

linear spacing along streets; and the requirements of the N.B.F.U. have been formulated on this basis. The area to be served by a single hydrant is determined by the fire flow required in the district under consideration. In the three cities in which the gate valve shut-off lengths were considered, it was found that, in the principal mercantile districts, the areas served by each hydrant were, respectively, 44,000, 54,000 and 68,000 sq.ft. The resultant spacing along the main streets were, respectively, 160 to 200, 160 to 180, and 180 to 260 ft. Another interesting fact is that, in these areas, of the 103 gate valve shut-off lengths which affect hydrant supply, 44 will put one hydrant; 30, two hydrants; and 11, three hydrants out of service; the remaining 18 lengths, mainly all in one city, affect from four to nine hydrants each. In residential districts, the distribution of hydrants is less concentrated, but, considering the lack of congestion and the activities of the civilian defense units, it will be generally adequate to handle the fires which may require the services of the fire department. Hence, it can be seen that hydrant installations in this country are generally well adapted for fighting fires during air raid attacks.

Perhaps there is some question regarding just what would occur if a supply main were hit and put out of service. In the N.B.F.U. files is the record of an excellent example, which occurred during the flood of 1936. The city in question is supplied by gravity from six impounding reservoirs through four normally throttled supply mains from three directions. During the flood, a 24-in. line was washed out and could not be shut off, due to the height of the flood waters, for twelve hours. By proper manipulation of the valves on the remaining lines, pressures were so regulated that the minimum reached in the principal mercantile district was 45 psi., leaving only 1 per cent of the consumers without water at any time. This shows much more clearly than any computations what can be accomplished during an emergency with a strong water system.

From the facts discussed, the author believes that, assuming the reports from England to be true, it can be concluded that American supply works and supply mains will not, in general, be seriously damaged; and that, due to the strength of their distribution systems, designed for substantial fire flows as well as domestic consumption, and the generally adequate number and proper distribution of gate valves and hydrants, American water systems can, in general, provide for civilian defense.

References

1. Bowman, J. British Water Works Practice. J.N.E.W.W.A., **53**: 394 (1939).
2. Standard Schedule for Grading Cities and Towns of the United States With Reference to Their Fire Defenses and Physical Conditions. National Board of Fire Underwriters. Jour. A.W.W.A., **34**: *pp. ff.* 1584 (1942).
3. Jordan, Harry E. Water Works Operations Under Emergency Conditions. J.N.E.W.W.A., **55**: 518 (1941).
4. Brush, William W. Should Bombs Come. W.W.Eng., **95**: 297 (1942).
5. Extinguisher 1433. Underwriters' Laboratories Report (March 19, 1942).

Civilian Defense and Public Water Supply

By Gordon E. McCallum

THE National Office of Civilian Defense, its regional offices and the state councils of defense have a common purpose—the protection of the local community, its people, its institutions and its properties, so that it may continue to make its maximum contribution to the war effort. Civilian protection in the local community is the mobilization of its resources and people to minimize the effect of possible enemy attack. Responsibility for local civilian protection rests with the local councils of defense which are the grass roots of the entire program. The key to progress in every aspect of civilian defense is the local defense council, through which all federal and state guidance must be effected, and without which federal and state effort would be mostly ineffective. No matter how efficient it may be, or with what authority it may be vested, however, the local defense council cannot do this job alone. Co-operation is essential—co-operation of individuals, co-operation of organizations and co-operation of municipal departments and public utilities.

The State of Virginia is fortunate in that its leaders have faced the problem in a realistic manner and have provided the machinery for its proper solution. The civilian defense legislation proposed by the Governor is impressive in its apparent practicability. It outlines a workable plan. Placement of the responsibility for planning and emergency execution of civilian protective measures in the hands of local government officials is a sound step. These officials know their communities and have the necessary organization to place civilian protection on a going basis in the least possible time and with the least dislocation of normal activities. Both the Co-ordinator of the Virginia State Council of Defense and the State Sanitary Engineer, who acts as the official representative of the state on matters of civilian protection of public water supplies, are well aware of the local problems and have, therefore, been able to give the utmost co-operation to the federal civilian defense officials.

Maintenance of Supply

Maintenance of public water supply is of paramount importance under any circumstance. Although water is the most abundant material on the earth's surface, local scarcities are not uncommon. Most water works men were familiar with the rationing of this commodity long before the present problems of general rationing arose. Water is

A paper presented on November 5, 1942, at the Virginia Section Meeting, Richmond, Va., by Gordon E. McCallum, Asst. Chief San. Engr., Office of Civilian Defense, Washington, D.C.

one of the most critical war materials. Public supplies must be maintained to keep essential industries operating, to supply fire-fighting requirements and to meet domestic needs. Failure to supply the requirements of any of these important uses will be extremely serious to the community concerned and will in turn lessen the effectiveness of the national war effort.

Often candidates campaigning for public office emphasize the importance of a single vote. They have pointed out, and proved statistically, that the effect of the failure of the individual to cast his ballot is great. This is equally true of the effect of the efforts of each local community on the total war effort; and it must not be forgotten how much the effort of the local community depends on the maintenance of a safe and adequate supply of water.

Failure, whether because of enemy bombing, sabotage, omissions of duty or personnel, will have the same result. Faulty operation, failure to chlorinate mains, failure to maintain sufficient chlorine residuals and faulty maintenance of plant are things which water works men must guard against if they are to do their utmost in serving their communities.

Contributions to War Effort

Various ways in which water works contribute to the war effort by adequately serving their communities have been mentioned. There is, however, another direct and very important contribution they can make—giving their full co-operation to the War Production Board in its tremendous task of placing a limited supply of critical materials where they will be of maximum use.

One of the more recent problems with which water works officials are being confronted is civilian defense. The Sanitary Engineering Section of the Office of Civilian Defense has devoted considerable study to measures which will more adequately insure continuity of water service in event of emergency resulting from enemy attack. Its recommendations based on these studies are outlined in Office of Civilian Defense Sanitary Engineering Bulletin No. 1.*

Organization for Emergency

Recommendations made to apply on a national scale must be general. A number of variables—geographical, political, governmental and legal—make this necessary. There are, however, general measures and plans of organization which are fundamental, and which can be adopted locally with little modification. A few of these general recommendations should be mentioned here.

The importance of the local council of defense has already been indicated. It is generally known that such councils have not always seen their problems clearly. At times they have seemed prone to neglect the protection of important utilities, including water works. Nevertheless they are the co-ordinating and operating agency of local civilian protection, and it is through them that the job must be done.

The first step in organizing the water works for the emergency is to see that its planning is integrated with that of the local civilian organization.

* Protection and Maintenance of Public Water Supplies Under War Conditions. Medical Div. Sanitary Engineering Bulletin No. 1, U.S. Office of Civilian Defense, Washington, D.C. (OCD 3030, Sept. 1942). This bulletin and Bulletin No. 2 of the same series are available to water works men through their State Water Co-ordinators.

This involves a complete understanding between the water works superintendent and the local commander of the Citizens Defense Corps with regard to training, planning and all other emergency preparatory activities of the water works. It involves arrangements for the placement of a representative of the water works in the control center and the proper identification of personnel and vehicles so that they may move about when normal traffic is restricted.

Command post exercises and drills are very important. Integration of the water works into the local civilian defense organization involves participation in rehearsals, with the water works organization acting as a unit under direct control of its own officials. Such exercises should be arranged and conducted in a realistic manner. Following each drill a careful analysis of performance should be made. If no weaknesses are revealed the test may have been too easy, in which case it can be made more involved by adding a few complications such as transportation or communication difficulties.

These phases of civilian protection may be looked upon as details of administrative overhead, but they are as important as knowing how to repair a broken water main or how to close a valve properly, because if preparations are not carefully made, the water works may find itself unable to function in an emergency.

Just as water is vital to the normal welfare of the community, it is essential to the protective program of civilian defense. The success or failure of local protection may very well depend upon an uninterrupted supply of water.

There should be little difference in what is expected from the national standpoint and what is expected from the local standpoint. Perhaps there should be more concern with what is expected from the local standpoint—what the people of the community expect of the water works. Everyone knows the answer to this question. The people will expect service to be maintained under any circumstance if humanly possible; if it is disrupted they will expect it to be restored as soon as possible. They will expect water works officials to institute and develop such measures as may be necessary to meet any foreseeable emergency. These measures constitute organizing the water works under effective leadership, not only for its own protection, but so that it may also be prepared to render assistance to its neighbors in the event of necessity.

Maintenance of Public Water Supplies for Civilian Defense

By Daniel W. Evans

PUBLIC water supply systems constitute one part of the national defense program. If they are maintained as they should be, the dangers from fire and disease are minimized. The subject of maintenance of an adequate and safe water supply is a wide one, but the author proposes to confine his remarks to the three points which he considers vital: (1) maintenance of the source of water supply; (2) maintenance of water service; and (3) maintenance of water safety. In this discussion there are a number of references to a paper by A. Carrington Wildsmith, Northern District Engineer, Manchester, England, Corporation Water Works,* which the author considers one of the clearest conceptions available of wartime maintenance problems.

Maintenance of Source of Supply

In the discussion of maintenance of sources of supply arises the question of adequacy of resources. It is well, in this respect, to consider what has happened in the past when droughts have occurred—springs have gone dry, impounding reservoirs have dried up, river intakes have been left high and dry and well yields have been reduced to little or nothing. These same conditions can be reproduced in a few moments by a well-directed aerial bomb. No single solution is available to overcome such conditions, but auxiliary sources of supply can minimize the danger of being left without a source. One or more of the following means can be employed:

1. The supply may be inter-connected with another approved public water supply. On this subject, Wildsmith has said: "Inter-connections with adjoining systems should be arranged on a mutual aid basis. Even a small alternative supply is better than none at all and may at least afford drinking water. These inter-connections have proved very useful."

2. The supply may be inter-connected with existing potable industrial supplies with the addition of treatment units. As is probably generally known, London has created additional reservoirs throughout the city by lining basements of demolished buildings to make them hold water. Wildsmith reports: "Some of these basements hold 1 mil.gal. or more and are connected to each other and the city canals by

A paper presented on November 3, 1942, at the North Carolina Section Meeting, Durham, N.C., and on November 12, 1942, at the Florida Section Meeting, Miami, Fla., by Daniel W. Evans, Regional San. Engr., U.S. Public Health Service, Fourth Regional Office of Civilian Defense, Atlanta, Ga.

* Wartime Water Works Maintenance in Britain. Jour. A.W.W.A., **34**: 179 (1942).

temporary steel piping fitted with pump unions. These reservoirs are chlorinated at intervals to prevent odor, but no connection is allowed between any static supply of this nature, or its pipings, and the street mains. Sprinkler systems connected to domestic mains may not utilize such water, but must run an entirely separate system."

3. Auxiliary portable pumping units may be used. It is not suggested that these measures be initiated now, but plans for maintenance of the source of supply should provide for them. It should be determined where inter-connections can be made quickly and with the least amount of labor and material and where such material can be secured with the least delay. The old principle of not depending upon a single unit for adequate service is much more acute in wartime than in peacetime.

Maintenance of Water Service

The consideration of maintenance of service may be divided into two parts: that which is concerned with "keeping what you have" and that which involves the repair of breaks or ruptured lines. The author will not attempt to discuss the mechanical operations of repairs to pipelines, but wishes to emphasize the fact that to keep the service operating is a tremendous task and one which has been underestimated by the majority of water works officials.

Planning has been guided too much by the manner in which mishaps have occurred in the past. Throughout the South, few cities indeed are blessed with large storage reservoirs of water ready for consumption. Generally, the pressure is equalized by a surge tank which rides on the line, taking in or giving out water as consumption demands it. A single break in a main distribution line will seriously reduce the pressure and flow of water in the whole system. To save the available supply of water, it is necessary to valve off the section of line in which the break occurs. This may mean closing anywhere from one to four valves. Naturally, delays, such as locating the service foreman, transportation of men, buried valve covers, lost valves, sticking valves, all add to the confusion and increase the danger and loss.

It is well to consider the time and energy used in closing a single 12- or 16-in valve. Many times, it requires a half-hour, with a crew of three or four men, to close a valve of this size. With additional valves to close, the time is increased in proportion. According to Wildsmith: "The great weakness of control systems is the sometimes unaccountable delay in the transmission [of messages]. . . . After a heavy raid, when many streets are blocked, traffic routes are in chaos until the police have charted up the through ways. . . . Even the priority label 'Repair Party—Water Works' cannot prevent delays in getting men and materials to the incidents. . . ."

If there were definite assurance that, during a bombing raid, only one break would occur at a time, with sufficient time for repair before another break, the situation would not be so critical. Modern warfare, however, does not seem to take this into consideration. Hearsay evidence points out that the plan of attack is first directed to vulnerable facilities, such as water works, followed by a mixture of high explosive and incendiary bombs. Such a plan needs no explanation.

Attempts have been made to estimate the chances of receiving hits according to the number of miles of pipe used in the distribution system. These calculations are based upon experiences

in England. Since there have been no similar experiences in this country upon which to base predictions, it appears rather impractical to say that, because a city has 200 miles of pipeline, its system may be expected to receive two hits. The type of war equipment is changing rapidly, day by day, so that the author believes that American water works men should assume a pessimistic viewpoint and be prepared for anything. Just because pumping stations have, to date, been reported untouched by bombing is no reason for assuming that they will not be bombed.

Regarding the number of valve crews, it is the author's thought that the maximum number possible should be trained. If men are not available, the services of women should be utilized. Certainly, women could handle the work of chlorination or emergency trucking of water if additional aid were needed.

Few cities in the South have made arrangements for trucking water into areas where the regular water service is out. This is sometimes a large undertaking and should receive more consideration. If the area out of service is small, the people may secure sufficient water for domestic use by carrying it from the next street, but, if the area is large in extent, tank trucks must be used. Wildsmith states: "The tank system may have to be extended greatly if the only trunk main to a city is severed in many places, as sometimes happens."

Maintenance of Water Safety

Every water works official realizes the responsibility which rests upon him to produce a water which is not only palatable but safe. To be safe for use, the water must be at least equal in quality at the point of consumption to that at the point of departure from the treatment works. Chlorination provides a simple inexpensive means of keeping the water supply safe.

At the time the United States entered the war, the Surgeon General of the Public Health Service, through the state health offices, requested water works officials to maintain residual chlorine throughout their distribution systems as a safety measure. In some cases, this has been done—in many more cases, it has not been done.

On this subject, Wildsmith has said: "Since the outbreak of the war, the Ministry of Health has ordered the sterilization of all drinking water, and, owing to its cheapness and ease of application, chlorination is practically universal. The method varies, some authorities working on the least possible dose to give a residual following the standard contact period, others maintaining a measurable residual in any part of the system, risking taste troubles in the interests of security. It has been found that, once people have realized the value of the precautions, they will tolerate some taste."

Assuredly, it will require more chlorine consumption than usual in peacetime, and it is known that chlorine is considered a semi-critical war material. Since the health protection of the people demands chlorine, however, it can be safely predicted that chlorine will be forthcoming.

Also from experience it is known that an unpalatable water drives the consumers to use other waters which may be unsafe. Therefore, every means must be used to prevent this from happening. For instance, it is known that ammonia combined with chlorine minimizes tastes due to chlo-

rine. This method, then, should be used to its greatest advantage. It is realized that it is difficult to procure chlorinators and ammoniators, but consideration should be given to some of the methods of application used in earlier days. Wooden vats are not difficult to construct and solutions can be fed continuously through a number of methods. Ammonium sulfate can be used in place of anhydrous ammonia.

Concerning the sterilization of mains following breaks in service, emphasis can best be achieved by quoting Wildsmith's statement: "One point is important—that is the removal of the sediment from the pipe invert. This may be soaked in sewage and, if left, forms a hard layer through which the sterilizing agent cannot pass. The water might then show a good residual and perhaps weeks later be in a dangerous bacteriological condition. . . . Mobile chlorinators are in common use, but the author does not consider their use on rush jobs worth while. . . . The author's opinion is that the easiest and quickest way is to use hypochlorite solution or bleaching powder in all circumstances, keeping the chlorine plants for use as continuous chlorinators in an emergency."

As a last point, it should be remembered that bacteriological analysis is the final check upon the efficiency of sterilization. As many tests as possible with the means now available should be made; and sampling, should, insofar as possible, be confined to the distribution system.

Summary

In closing, the author would like to summarize the points he has made and emphasize them with the thought that something should be done about each of them in every water works.

1. Auxiliary pumping units, sources of supply and emergency tank services should be developed even though they may never be used. At least, an operator should know what he can get and what he can do with it, when necessary.

2. Maintenance crews for shut-off and chlorination services should be expanded as much as possible. These crews should be trained in their duties constantly and religiously.

3. A safe water should be maintained at all times and at all points on the distribution system. There should be no fear to risk a little chlorinous taste in the interests of safety.

Use of the Emergency Alternate Specifications Alum

By Fred E. Stuart

MANY water works men are wondering why it was necessary to suspend the A.W.W.A. Standard Specifications for Sulfate of Alumina in favor of the Emergency Alternate Specifications adopted by the Board of Directors at the Chicago Conference (*see* Jour. A.W.W.A., **34**: 1073 (1942)). To the water works operator the modifications involved in this change will mean some inconvenience in making necessary the more frequent cleaning of the alum-dissolving chamber. The new type of alum will also involve the installation of a water eductor on solution lines if any great distance is involved. It will involve the installation of water jets in the dissolving chambers under some dry feed machines. It will involve more dust in the alum. It will involve more frequent caking and arching in the hoppers. It will involve lumpy or caked alum under some weather conditions; and, in the long run, it will involve an increase of 10 or 15 per cent in the amount of alum required for similar clarification of most water most of the time. Operators are entitled to an explanation of these conditions, especially in view of the fact that the new type of alum still costs as much as the old and will cost more if present conditions continue for any great length of time. It is the purpose of this paper to give such an explanation, discussing each of the above-mentioned difficulties in turn.

Causes and Cures

The inconvenience of more frequent cleaning of the dissolving chamber will result from the increase of insoluble material in the new type of alum, in which 15 per cent material insoluble in distilled water is allowed under the emergency specifications.

Installation of a water eductor will be necessary if there are any low sections in the alum feed line, since such sections will become filled with accumulated sediment unless they are flushed through the line at a high rate of flow. It will be found that the operation of a water ejector or eductor in the alum feed line for about five minutes after the dry feed machine has been shut off will remedy this clogging. Such practice will be found especially helpful in plants where the machines are operated intermittently.

The installation of water jets in the bottoms of dissolving chambers (using a ¾-in. supply line reduced to ⅜-in. pipe size by a ⅜-in. cap drilled with three ¼-in. holes) will accelerate the dissolving of the new type of alum.

A paper presented on November 6, 1942, at the Virginia Section Meeting, Richmond, Va., by Fred E. Stuart, Pres., Stuart-Brumley Corp., Baltimore, Md.

The high water velocity of these jets will stir up the insoluble content and carry it over to the feed line where the water ejector will pick it up. This is an extremely important feature in the feeding of the emergency alum, because the insoluble content will then be carried from the dissolving chamber and will be deposited in the mixing chamber. It will readily be seen that if insoluble material is built up in the dissolving chamber under the dry feed machine, the detention time would soon be reduced to the extent that the alum would not have time to dissolve before it entered the feed line and mixing chamber.

The dustiness of the new type of alum is a result of the higher basicity which must be carried because of the greater amount of clay and silica in the type of bauxite which the W.P.B. now allocates to the chemical manufacturers.

The caking and arching of the emergency type of alum is the result of the lack of experience of many of the alum manufacturers in handling the bauxite of different chemical characteristics now available to them. This difficulty should be overcome in the next two or three months as manufacturers become more accustomed to extracting the available alumina (Al_2O_3) from the varied ores now being supplied.

The difficulties of lumping or caking arise in converting a mineral to a sulfate where two-thirds of the finished product is sulfuric acid. A filter alum is extremely hygroscopic, and the moisture that it so readily picks up causes the particles to form into a lump or into hard cakes, according to how much it has been able to absorb. The greater frequency of difficulties from this cause should also be overcome gradually as the manufacturers gain experience in handling the new bauxite and as operators realize the greater importance of storing the alum in a dry place.

The final problem that the new specifications have raised is that of an increase in the quantity of alum required. The new product will average from 14 to 15 per cent water soluble alumina (generally recognized as the active ingredient of all filter alum) as compared with the 17 to 18 per cent required in the superseded standard specifications. In some waters, of course, the highly acid-charged insoluble concentration of the alum will aid coagulation. Since the new emergency specifications parallel the "Activated Alum and/or "Black-alum" product in some respects, some operators may not notice the 10 to 15 per cent reduction because the acid-charged insoluble concentration may help in floc formation in spite of the reduction in alumina. It will be noted, however, that in the majority of instances the amount of alum needed for the same degree of clarification will increase in direct proportion to the reduction in alumina content.

In this same respect arises the question of why the emergency type of alums cost as much as the standard high-alumina type. The explanation is simple—the lower quality raw material (bauxite) costs just as much as the higher quality ore, since it requires the same amount of handling in the mines. Similarly the processing involved in the manufacture of the alum is just as expensive.

The Facts on Bauxite

The difficulty of obtaining good bauxite has been referred to as the main reason for the modification of the alum specifications. Most operators know that filter alum is mainly a

combination of bauxite and 60° Baumé sulfuric acid, the ratio being roughly one part bauxite to two parts sulfuric acid. The bauxite previously used for the manufacture of filter alum contained from 2 to 8 per cent silica (SiO_2), which is undigestible in sulfuric acid. The present type, however, must contain over 15 per cent silica, and may, in some instances, contain as much as 30 per cent. The iron content generally increases with the percentage of silica.

From the fact that silica is undigestible in sulfuric acid, it is obvious that there will be greater difficulty in extracting the alumina from the poorer quality ores. Likewise, the fact that part of the alumina is very tightly bound with the silica and iron will result in finished alum that is lower in alumina and much higher in silica and iron, both of which are insoluble in sulfuric acid and distilled water.

It has been necessary for the W.P.B. to allocate high silica bauxite to the chemical industry for two reasons:

(1) Although the domestic supply of bauxite is sufficient for all purposes, there is a shortage of high-grade ore; and although this high-grade ore could be obtained from South American deposits, the ships required for its transportation are now being used to better advantage in more direct contributions to the war effort.

(2) The limited amounts of high-grade bauxite available from domestic deposits have been allocated to the aluminum industry primarily because the individual difficulties resulting from the use of lower quality filter alum will be minute as compared with the problem of converting aluminum extraction plants to the use of low-grade bauxite. The fact that this aluminum is going directly into the manufacture of airplanes and that nothing must stand in the way of peak production in that field must also be considered.

From these facts it will be obvious that the temporary inconvenience to water works operators resulting from the use of the high-silica alums is a necessary step toward furthering the war effort. No water works man can consider the difficulties involved a hardship in view of their necessity. For their part, the manufacturers in the field have promised the water works field the very best quality of filter alum that can be made under present conditions.

Substitute Materials in the Water Works Field

By Richard Bennett

ANY subject which can create so many headaches to operators, designing engineers and manufacturers as that of substitute materials certainly deserves comprehensive study. In this paper the author has attempted to present the over-all study that is required, but, because of the scope of the subject, has been able to give little more than a thorough outline of some phases of the problem.

When this country was drawn into the war, its enemies were prepared and it was not. Since then, the necessary preparations have created great needs for available materials, one result of which has been that water works have had to resort to substitute materials and methods to meet operating exigencies. The country is well supplied with natural resources, but it must prepare for war NOW, not *mañana*—therefore the accent on availability of materials.

The present situation involves a shortage of critical materials, which makes them unavailable to water works for the maintenance of adequate and dependable service. There is no doubt but that the War Production Board regards efficient maintenance and operation of water systems absolutely essential to the war effort, but the very purpose of the priorities system has been to make it difficult, rather than easy, to obtain supplies made from critical materials. The need must be genuine and proven. Water works must revaluate past standards and accept new—perhaps unproven—ones. The problem at the present time is not one of obtaining materials for new construction, for priorities have practically stopped this, but of obtaining the materials necessary to meet operating contingencies. The problems of different water works vary greatly. Public water works are expected to have a long life; therefore, if new construction is essential and permitted it should be undertaken with reliable materials if possible.

Critical Materials

Water works must be operated to meet only essential needs. The War

A paper presented on October 30, 1942, at the California Section Meeting, Oakland, Calif., by Richard Bennett, Hydr. Engr., Municipal Water Works, Phoenix, Ariz.

EDITOR'S NOTE: The reader should note carefully that this paper was prepared for presentation in October 1942. It is suggested that the reader assume that the ratings cited as necessary at that time are in all probability higher now.

For further discussion of this subject it is suggested that the reader review the translation of the German article entitled "Domestic Materials in the Water Supply Industry," covering the use of substitute water works materials in Germany, which appeared in the Abstracts section of the July 1941 JOURNAL (p. 1271).

Production Board wants water works to have the material and equipment needed to assure adequate service, but at the present time there is an insufficient supply to meet all demands; therefore, critical materials can be used only when there is clear and definite justification.

New equipment should not be requested when old equipment can be repaired or rehabilitated. If critical materials are to be conserved, the "p & p," i.e., "patch and pray," method must be applied to a greater and greater extent. Standby equipment should not be requested on the mere pretext of safeguarding public health—available equipment should be repaired and made to serve a useful life.

If water works are to be kept operating under existing conditions, such materials as are available from time to time must be utilized. Brass, copper, iron and steel are the materials which are scarce today, and those which are most needed by the water works industry; but many other materials are available.

Brass materials require a priority rating of A-1-k or higher, but water works can assign a rating of A-1-c * to not more than 30 per cent of the materials within any class scheduled for delivery in each calendar quarterly period, which materials are required for repair of an actual breakdown of existing facilities, or to make reasonable advance provisions for such repair. If through unusual circumstances this does not produce sufficient brass goods, a request may be made to the Priorities Division on form PD-1A for a rating of A-1-k for the materials needed.

Restrictions on steel are very severe. Very little steel seems to be available with a rating of less than A-1-a. If steel or its products must be used, the "National Emergency Steels," that have been developed as a result of cooperation between the War Production Board and members of the Technical Committee on Alloy Steel of the American Iron and Steel Institute, should be used to the greatest possible extent. This list contains many grades having a range in carbon content of 0.22–0.52 and containing carburizing, medium-hardening and full-hardening steels. The purpose of the emergency steel is the conservation of the critical alloys, such as molybdenum, nickel, chromium and vanadium. Emergency steels are divided between manganese molybdenum content and nickel chrome molybdenum content. Information on these steels may be obtained from the American Iron and Steel Institute. Any forgings are difficult to secure; therefore, cast metals should be substituted wherever possible.

There is little doubt but that, eventually, plastics will find broad application in water works practice. Plastics, which are waterproof, which will withstand high pressures, which are impervious to heat and which will withstand alkalis and acids, are now being manufactured; but it must not be inferred that plastics are the solution to the present materials shortages. In many instances, plastics which are good alternates are composed of materials more critical than steel, copper and rubber.

Local staffs should be called together and told frankly that the use of critical materials—that the use of all materials—must be reduced. This method will undoubtedly discover the fact that the problem is not so urgent as it appears. Government officials do not think that

* AA-1 after Jan. 1, 1943.

the critical materials situation will improve before 1944.

Substitute Materials

No one could do justice to this subject and confine the discussion within the literal definition of its title. The words "substitute materials" must be broadly interpreted to include alternate materials and engineering methods. Practically every material mentioned here has seen service in water works in various uses for varying periods of time, but inquiry reveals that few water works men are familiar with all these uses.

A substitute material must possess two main qualities: strength and noncorrosiveness. For some uses, proper corrosion protection features may be applied. Such materials must not possess qualities which render the water objectionable. A little research and imagination will reveal the fact that there are many possible substitute materials available for nearly every water works need, but that, because of lack of experience in employing these materials, they have not been extensively used. Substitutes for metals are not likely to be adopted quickly, because there is a widespread lack of concentrated effort on the part of water works to do the necessary experimental work. Metals have been used so long that it has become second nature to insist upon their use. It is natural that there should be a hesitancy to adopt materials, the reactions to use of which are not familiar. The cost of developing substitute materials is generally too great to be assumed by individual water works or operating companies; it is too great, too, for a single manufacturer, unless he is assured of sufficient output to make the venture worth while. It is certainly reasonable to state, then, that a concentrated development program is in order if water works are to secure needed materials.

The materials mentioned in this paper should be considered functionally on their own merits, not as mere substitutes. Many of them will prove not inferior in any sense; in fact some will be superior.

Meters

It has been the practice of many water works to scrap all meters when the cost of any one overhaul approximated 50 per cent of the cost of a new meter of that make. No longer is it good business to hold to such rule. The whole question now is whether it will be possible to secure repair parts or not. Limitation Order No. L-154 definitely restricts the use of certain metals in the outer case, lid, bonnet and register plates.

Cast iron seems to be the most used material, other than bronze, for the main case; therefore, several meter manufacturers are now producing iron-case water meters, thus conserving from 65 to 80 per cent of the bronze formerly required. Iron-case meters have been in constant use in some water works for 35 years and are still giving satisfactory service; in fact there is a noted difference in the usable life of bronze-case meters, due to varying water conditions. Most meter companies have always manufactured their large-case compound and turbine meters with cast-iron housings. There will be no fundamental changes in the design; therefore there will be complete interchangeability of parts, so that if, after the war, it is desired, the iron cases may be replaced.

The cast-iron cases are generally chemically treated to prevent corrosion. Many methods are available for this

purpose, but none seem to be widely accepted at this time. Some manufacturers place lead-alloy liners in the cast-iron base, preventing contact with the bronze measuring chamber, to eliminate corrosion, thus permitting easy removal. This may overcome some of the objectionable features of cast iron for this use. The W.P.B. used good judgment in requiring meter manufacturers to use substitute materials only for the bronze case and register box. If meters were not provided, the peak consumption and daily use rates would be so great in some instances that it would be necessary to increase all other facilities to provide adequate service. It is no longer possible to use tin dipping, electro-tinning, chrome plating, monel metal, nickel alloys or stainless steel for meters. The materials most likely to be used in the manufacture of cold-water meters will be somewhat as follows:

Registers: Steel for upper and lower plates and backing of dial

Gear Trains: Bronze

Chambers: Bronze

Discs: Rubber or substitute materials (Plastics which have been made for meter discs seem satisfactory in every respect; they will withstand temperatures up to about 100°F.)

Main Cases: Cast iron

Register Boxes: Cast iron, glass, plastics, etc.

Main Case Bolts: Steel

Packing Materials: Synthetic resins and even suitable forms of pasteboard (Phosphor bronze or similar metal will probably be substituted for monel metal.)

Strainers: Probably untinned copper

Gears and Cases: Possibly artificial resins.

Excess use of water creates the need for large water mains. Such requirements may be curtailed by 100 per cent meterage; therefore, the meter repair and installation programs should not be permitted to lag.

In connection with the automobile travel required to read scattered meters and the consequent required use of rubber tires, many water works are considering the possibility of permitting customers to read their own meters, merely marking a prepared form postcard with the location of the various meter index hands. With a proper set-up the savings made would be much greater than the mere saving of rubber.

Meter Boxes: Where not subjected to traffic conditions concrete has long been found equal to or superior to metal for meter boxes.

Services

Copper: No longer is copper tubing available for services, but there are several substitutes, some of which have been used as standard practice by many water works.

Cast Iron: Cast iron with screwed joints is available in 1¼-, 1½- and 2-in. sizes and may be had in 6-, 12-, and 18-ft. lengths in the two smaller sizes and in 9- and 12-ft. lengths in the 2-in. size. It is usually permanent, but some object to the brittleness of the metal for this use. Many use malleable fittings for all direction changes with cast iron.

Lead: Lead has long been found a satisfactory material for services by many water works. The Lead Industries Association reports: "At the present time [September 1942] only about two-thirds of the lead available each month is actually going into consump-

tion and the Government has a large stockpile of lead to take care of emergencies. . . . There are no priority problems involved in obtaining lead service pipe, or calking lead. . . ." Tin is required if soldered joints are used, but manufacturers are permitted to make wiping solder, containing up to 38 per cent tin, for the installation of lead water service pipes until January 1, 1943.

Lead pipe of XS or XXS weight may be secured for services up to and including 2-in. size. Lead will not withstand exceedingly high or water-hammer pressures, otherwise it is permanent, ductile and reliable. Due to the trouble in securing flanged fittings because of the extra metal involved, it will probably be necessary to use wiped joints exclusively with lead. Prevention of the use of tin in solder may eliminate lead service pipe for the duration. In some places lead pipe is prohibited for health reasons.

Steel: Water works are now receiving black steel butt-welded pipe in sizes up to 2½ in. in diameter, when and if their priority rating is sufficient. Local conditions may require various forms of protection for this material. In badly tuberculating waters, it is best to secure this product cement-lined. If the soil is quite corrosive, it is economical to provide protection in the form of tar coating and wrapping. With coating and wrapping, most trouble is experienced with poor workmanship in making field joints.

Cement-Lined Pipe: No priorities are required for cement lining. Most water works can secure black steel pipe, which may be cement-lined. Under some conditions this makes the pipe superior to the galvanized pipe or to that of some other material. When the cement lining is properly applied there will be good bond and uniform thickness; the lining will be homogeneous and will meet required tests for bending, vibration, shock, cutting and threading of the pipe. In highly corrosive waters cement-lined pipes now have a good record of more than 60 years and seem to resist the action of waters which affect copper and lead.

Wrought Iron: Wrought iron has been successfully used in many localities, having qualities of strength and workability. An analysis of the water should be made to determine the suitability of wrought iron. Water of low pH or high in carbon dioxide will react with the metal. The iron mills offer consulting service in this respect. If black wrought iron is used, the pipe should be pickled at the mill to remove the oxide coating produced in the manufacturing process. This treatment decreases the tendency of corrosion to localize and removes the inside scale so that it will not later cause clogging. It may be secured in standard sizes.

Tube-Loy: "Tube-Loy" is a relatively new product of the American Smelting & Refining Co. This metal is extruded from a patented lead alloy to which has been added small amounts of magnesium, calcium and tin, which improves the physical characteristics of lead, the principal component, extending and increasing its utility. The manufacturer claims low initial cost, simplified construction, greater ductility and enduring performance. Malleable galvanized iron flared fittings are furnished for "Tube-Loy" by the Grinnell Co., which claims these will prevent leaks due to vibration and shearing due to too great wrench pres-

sure. Full satisfaction is not reported in all cases.

"Tube-Loy" should not be used where the water is corrosive to lead or lead-alloys. It permits the use of standard joints of wiped, flared or solder-feed fitting and may be had in standard sizes up to 2 in. in diameter. This product has been in service about four years, and many installations are available upon the basis of which its usefulness can be determined. It is simple and easy to install. The physical strength is far greater than lead, which is a disadvantage of that material. The wall thickness is several times that of copper. Many large cities have changed their codes to permit installation of this metal.

Plastic Tubing: Plastic tubing may be had in different wall thicknesses to meet almost any pressure condition required. Flared joint fittings may be used. It possesses great strength and may be curved to meet any construction condition. It serves well for installation of pressure and flow instruments, etc. Most plastic tubing becomes brittle with drop in temperature and is not adapted for use with hot water. It is now available in sizes up to 2 in. in diameter.

One plastic tubing, "Saran," is made of a chemically resistant thermoplastic resin. This product seems to offer almost unlimited possibilities to water works. The weight is approximately one-fourth that of comparable sizes of iron pipe. The softening point is 240–280°F.

Distribution Mains and Small Pressure Lines

For small pressure lines the use of asbestos-cement has been widely adopted.

For the inner protection of metal distribution pipe, the material most readily available is cement. Placing of such lining by the centrifugal method gives the best results and may be done locally.

Centrifugally-spun concrete pipe may be secured in 6-, 9- and 12-in. diameters, made in 8-ft. lengths. This pipe will operate under pressures up to 100 psi. Services may be attached by use of saddle and straps, or by metal pipe couplings inserted during manufacture. The very simple calked-collar type of joint is used.

Tinless bronze is being used to some extent in small-flange lines requiring bronze. These copper-silicon-iron alloys are replacing the tin bronzes in many places.

Supply Lines

For large pressure lines, the use of a steel shell coated inside and out with concrete utilizes the least amount of critical material, but due to the scarcity of steel it may be necessary to use materials, the characteristics of which have not yet been proven.

Non-pressure gravity mains could be built with unreinforced thickened shells, laid in a substantial cradle of lean concrete. These may be constructed of tile, brick or other non-ferrous materials.

Before concrete pipe is adopted, tests should be made to determine that the quality of the water passing through the pipe will have no deleterious effect on the pipe material. Tests should also be made of the suitability of the soil for the material which is being considered.

Vitrified clay pressure pipe is being used to some extent, but developments to date are not sufficient to justify their marketing, although research and

experimental work is being actively conducted along this line. The most pertinent statement in developing a clay pressure pipe is that of Benjamin Eisner, Chief Engineer of the Clay Sewer Pipe Association, who states that the problem "is that of attempting to reduce, rather than to eliminate, the amount of metal normally needed, by using a precast section containing three materials: vitrified clay sewer pipe, concrete encasement and cast-iron stubs at either end. This device would comprise two, three, four or more sections of clay pipe prejointed with bituminous material, and having short pieces of bell and spigot cast-iron pipe at either end. All except approximately 2 ft. of the spigot end of the iron pipe would be encased in concrete prior to installation. Thus, one bell end of the iron pipe would be encased, and 24 in. or so of iron pipe would be exposed to provide room for joining and for insertion of service tappings. Fittings, of course, could be inserted in the conventional manner."

Vitrified clay pressure pipe is now used for pressure heads of over 100 ft. The inside finish is comparable to bathroom tile. The lengths are from 4 to 8 ft. A coupling type of joint with sulfur compound is used. For water supply lines operating under small pressure head, this type of pipe would seem to meet almost every requirement. This pipe is in a stage of development and represents a trend rather than an actual offering to the public at the present time. Some installations have proved quite successful. The pipe is made with a separate collar joint similar to asbestos-cement water pipe. The Research Department of Ohio State University is now engaged in research to adapt vitrified tile pipe to water works uses.

Distribution Pressures

If pressures are low in the distribution system it is not always most economical or necessary to install additional feeder capacity. A proper analysis of the system will indicate where storage, either ground or elevated, may be provided and fed into the system during hours of peak consumption to maintain pressures. Many water works have found that pressures may be maintained with less than 25 to 50 per cent of the maximum drop in static levels which are experienced without such storage service. This may be accomplished not only with great savings in construction costs, but also with small quantities of vital materials in comparison with constructing new mains.

In most cases it is better to install ground storage and pumps rather than elevated storage, but, where elevated storage is essential, the use of wood and concrete will require a minimum amount of critical materials. Design practice has now been perfected so that it is perfectly practical to build elevated tanks, of almost any desired height or capacity, of wood with timber substructures or of concrete with concrete substructures.

Often elevated storage may be made unnecessary by the construction of ground storage which will partially or totally take its place. This method permits of maintaining a load factor on the main supply pumps of 90 per cent or more. The first cost of this method is considerably less, but the capitalized maintenance costs approximate the actual costs of the more desirable types of distribution.

Storage tanks should be designed of unreinforced concrete with trimmed excavation for the outside form. Roofs

to carry any desired load may be designed of unreinforced concrete of groined-arch construction.

Restoring Capacity of Mains

Restoration of original carrying capacities may not only help the war effort by eliminating the need for extra pipelines, but may be the only solution of the problem of increasing existing main capacities. There are no priorities on water main cleaning, as such, but priorities are required for the small amount of metal in the cleaning equipment and for insertion point hook-up couplings. Supplementary water mains are not possible in all cases, but cleaning of existing mains may supply the necessary and desired service at a fraction of the cost of new pipes. Simple hydrant flow and pressure tests show exactly whether or not cleaning of the main is desirable. Cleaning of water mains may be done advantageously either by contract or by utilizing the water works own forces and renting the necessary equipment on a per foot basis. No amount of ingenuity with construction methods can increase flow supplies so rapidly.

Cleaning will restore to almost original carrying capacity those water mains partially filled with sand, extruded lead joints, blocks left from construction, partially closed valves, tuberculation, etc. One can never fully appreciate what is in the water mains until they are cleaned. Published reports state that in New York City a wheelbarrow was flushed out.

Cleaning may not only eliminate the need for extra pipelines, but may justify fire insurance rate reductions. It is not uncommon to find pipelines rendering 50 per cent or less flow capacity, restored to 95 per cent original flow capacity by cleaning. Cleaning lowers friction losses, with consequent lowered power bills—another way to help the war effort.

Many water works have many miles of water mains which could be cleaned profitably, thereby increasing their carrying capacity from 25 to 50 per cent or more. This is especially true in the case of the larger cast-iron feeders whose lost capacity must either be replaced by cleaning or supplemented by the construction of new mains. Cleaning conserves these vital materials. The cleaning can be made permanent by several of the lined-in-place methods now offered to the profession.

It is not unusual to find that ordinary pitch-lined cast-iron water mains lose carrying capacity quite rapidly. In some sections this may be as fast as 1–1½ per cent per year with the loss not leveling off for perhaps 35 to 50 years after the pipe is laid.

Modern pipe cleaning technique and equipment definitely prove that cleaning does not harm existing water mains or require raising the pressure, thereby causing blow-outs in the weak joints and badly pitted sections; nor are corporation stops loosened by cleaning procedures.

Distribution System Surveys

If the distribution system is entirely inadequate to meet existing needs, pipelines should not be added until a thorough investigation has been made of the hydraulics of the system. This is good economics whether materials are scarce or plentiful. In one case with which the author is familiar, a two million dollar feeder main was added and failed absolutely to correct the deficiencies for which it was installed. A detailed hydraulic analysis would have shown beforehand that such construction was useless.

Much unnecessary consumption of water can be eliminated, especially leakage from distribution systems and the unnecessary wastage resulting from flat rates. If leakage were eliminated, that factor alone would greatly increase capacity, storage and pumping facilities.

Bell and Spigot Pipe Joints

In the milder climates there is little excuse for not using portland cement for all joints in laying bell and spigot pipe. This product entails minimum cost and is plentiful at this time. Cement joints are now standard practice in many water works. Some report they have successfully used this jointing material in the colder climates.

Lead for calking is freely available either in bulk form or as lead wool. If aluminum becomes plentiful, the aluminum wool may be used.

Various types of materials for yarning bell and spigot joints have appeared on the market, but these are mostly made of rubber, a vital material no longer available. Cotton yarning material seems to be perfected.

"Fibrex," a paper product, is another comparatively new material available as an alternate for braided jute.

Valves

Satisfactory substitute materials have not been found for gate valves, hydrants, check valves, air valves and such equipment. It is possible that all-iron valves may be the wartime substitute. Tinless bronze is being used some for valves. Effort should be made to substitute plastics for bronze in certain valve parts.

The simplification of valve practice now advocated will prevent strict compliance with the A.W.W.A. specifications, in respect to the "extra bronze mountings," such as collar seats, bronze glands, gland bolts and wedge facing on the disc. At the present time some valve manufacturers do not contemplate discontinuance of bronze for seat and disc rings, and some are continuing the use of bronze for non-rising stems and nuts.

High-grade cone valves are difficult to secure; therefore many are now substituting ordinary flap check valves with the flaps weighted to cause closure before the reverse flow of water occurs.

Sluice gates for plants serving war needs might be made of hard wood.

Valve yoke sleeve nuts may be of steel or malleable iron, but in freezing climates, this subjects the valve to freezing. Some contend that the saving in critical materials is not consistent with the dangers involved. Valve stems might be made of carbon steel, but this again is a very critical material. Steel will be used for the outside screw and yoke valves, steel nuts in the stuffing box, etc. Plain bolts may be used in place of rust-proofed bolts. Bronze bushings, with the possible exception of the gland bushings, may be eliminated.

High tensile strength high copper mixtures which require the addition of the very critical virgin metals could well be replaced for the duration with a bronze composition of 85–5–5–5 per cent, made of secondary metals which are comparatively plentiful.

Gear cases and gear covers might well be eliminated except in those locations where deemed essential. When rubber valves or rubber cap gaskets are specified these may be eliminated in favor of leather, which is now obtainable.

The National Bureau of Standards is endeavoring to standardize valves. In 1939, the sale of bronze valves

showed 97 per cent to be in five pressure classifications, the other 3 per cent involving six other pressure classifications. The sale of iron body valves showed 95 per cent to be in three pressure classifications, the other five per cent requiring nine other pressure ratings.

The "Simplified Practice Recommendations" are that the bronze or brass valves, sizes ¼ to 3 in. inclusive, be reduced to five pressure classifications, as follows: 100, 125, 150, 200, and 300 psi. working saturated steam pressure.

The recommendations for iron body valves are that they be reduced to three pressure classifications, as follows: sizes 2 to 12 in. inclusive, 125 and 250 psi. working saturated steam pressure; and sizes 2 in. and smaller, to 150 psi. working saturated steam pressure.

The above eight standard sizes eliminate 15 pressure classifications now used on a very small percentage of the total valves sold. The shifting of consumer demand to these standard types will free men and machines, thereby making possible an increase in the total industry output and aiding in the conservation of materials.

Valve Boxes: Concrete has long been found equal to or superior to metal for valve boxes. For traffic locations these are furnished with cast-iron tops. This eliminates about two-thirds of the metal and furnishes a product that is fully as serviceable. In non-traffic areas, only about five pounds of steel are required, with consequent great savings in cost. For traffic areas, successful practice involves the use of vibrated concrete and specially designed reinforcement cages.

Hydrants

Wrought iron is now advocated for fire hose couplings, but this material is not fully suitable for such use. For this purpose, a safe product other than copper is not known. Nozzle chains might well be eliminated. They could be added later if desired.

Pumps

Pump manufacturers are doing everything in their power to use less critical materials and still manufacture quality equipment. Their designs and shop practices have undergone radical changes. Accelerated tests show that the same years of service may be expected from the wartime products of the better manufacturers.

Tinless bronze is now being used for pump impellers, bushings, and pump bodies. This bronze is better for pressure castings than the tin bronzes and the metal cost is not increased.

The art of making iron castings has advanced quite rapidly in recent years; now suitable cast-iron pump impellers are being furnished by several manufacturers. Some use porcelain enamel, which helps to conserve the badly needed copper. If pumps are necessary and proper priority ratings are difficult to secure, this type of impeller should be given consideration in the specifications.

Chrome-plated steel shafting is used instead of stainless steel; close-grained steel may be used instead of copper steel for column pipe. The bowl shaft bearings may be of cast iron. The line shaft bearings may be of iron having sufficient tensile strength. Changes such as these eliminate the use of large quantities of stainless steel, bronze, monel metal and copper steel.

For repairing pumps, whether parts are difficult to secure or not, consid-

eration should be given to metallizing, i.e., building up the worn parts by the hot-spray process. Shafts, rings and impellers may be recovered by this method.

If a pumping station is needed, it is not absolutely essential that spare pumping units be provided. Most water works men well know that many pumping units have given years of trouble-free service. Some gamble in this respect is justified.

If extra pump capacity is needed, it may be a matter of testing the existing pumps and determining if they are delivering at maximum capacity and efficiency. It is true that the pumps in many water works are seldom, if ever, checked for efficiency. The operator of one 4-mgd. station complained that his pump capacity was diminishing. It was suggested that he remove the upper case and examine the impeller and pump interior. Next day he reported finding a $2 \times 4 \times 21$-in. timber lodged in the suction; swollen until it had increased 50 per cent in size. At the start of his story he was ready to install another pumping unit. An analysis of his power bills showed that he had spent more than $3,000 in unnecessary power purchase because of that timber wedged in the suction for several months.

Wells

In many communities ground water is more economical than stored water; therefore drilled wells can be used to advantage.

In some ground formations metal well screens and casings corrode so badly that they require replacement in a few years. Concrete well screens have been used for more than 25 years by American manufacturers and all inherent faults, both in manufacture and methods of installation, seem to have been overcome. Perfected centrifugally spun concrete screens and casings are now available in sizes up to 17 in. in inside diameter. They may be placed to depths of 400 ft. and are designed to meet all conditions of surface inlet area in relation to retained casing strength.

Concrete well screens seem to meet all requirements of strength to stand up against ground lateral pressure and to carry the vertical load, as well as to provide adequate inlet openings to admit freely all available ground water. Due to the weight involved, these casings and screens must be made in short lengths to facilitate installation. Existing concrete casings and screens have mostly been made with standard mixtures, except that small sizes of aggregate are used. The openings diverge and become larger on the interior.

Wood pipe casings have long been used for the shallow cisterns, bucket wells, etc., but at the present time no manufacturer is in position to use this material for deep wells. Much steel wire is required to hold the stave sections in place. A wood drainage pipe is now on the market, in which small sections of wood are fitted together with wooden pegs, which basic design might be adapted for use in deep wells. Red cedar and cypress seem to be the best woods for this purpose.

Asbestos-cement pipe has been successfully used for casing and screens for shallow wells. This material should be very successful, but development work is needed to design proper joints.

Asbestos-cement pipe is particularly well suited for gravel-packed wells, for both casings and screens. Being noncorrosive, it should maintain full flow

permanently and obviate the need for cleaning or removing screens. There are several known methods for screen construction with this material. The screen openings are designed to meet local conditions. This pipe may be used for screens up to 36 in. in diameter. The annular space around the pipe is generally packed with selected gravel, and the well then surged in the regular manner, with the surge tool well wrapped with rope, alternately surging and pumping.

"Styrene" or "Vinyl" resins seem to be suitable plastic materials for the manufacture of well casings and screens. Active research work has been done for more than a year to develop suitable well casings and screens of these materials, but the large sizes required have not been successfully produced. The future will probably see proper price adjustments in this material. Plastics have many advantages in that they can be developed with immunity to water and chemicals, can be shaped easily and are comparatively light in weight.

Oil field installations have been made with such materials as a fiber conduit composed of approximately 25 per cent macerated wood fibers and 75 per cent coal-tar pitch, which mixture is unaffected by corrosive water. This conduit is available in small diameters, but the inherent weaknesses of the material necessitate careful installation methods.

Caisson ground water wells require vital materials, which requirement can be eliminated with drilled wells using non-ferrous screens to good advantage.

A thorough study of oil field practice may develop more practices adaptable to water well uses. The use of fiber casings lined with resins to harden the surrounding materials may offer a basic solution. It might be possible to form a casing of injected cement, with a core form, in which is mixed large granules of calcium carbonate which would dissolve, thereby forming a screen. There are so many possibilities of developing new well casings and screens that it is not possible to list them all here; yet much development work must be done if they are to be made available.

The use of tile, earthenware and glass, as reported from Germany, probably has too many limitations for widespread use here. These materials are easily fractured, difficult to install, quite costly, require metal fastenings and do not possess sufficient strength to be installed at great depths. Such materials naturally would not withstand the strains which might be absorbed by steel, but competent well drillers could adapt their installation methods to the material.

Filters

No filter capacity should be added until present filters are producing their full 24-hour rated capacity. Some plants have increased capacity by utilizing super-chlorination, which also acted to better the water quality. Filters should be operated somewhat over rated capacity if necessary, to conserve vital materials. With well screens as suggested above, it is is possible, in many places, to drill wells which will relieve filter capacity.

Where the filter is to provide service for only a few years, some are eliminating the concrete bottom, placing open-joint tile directly on subgrade and depositing the broken stone over this. It is well at this time to study the design of the older water plants, which were built long before reinforced concrete was introduced.

Vitrified clay pipe has now been used for water filters, successfully meeting internal pressure requirements of 25 psi., one successful installation being in the Los Angeles Metropolitan Water System. The pipe used there was 4 in. in diameter and was made in 5-ft. lengths.

Softening

If a softening plant is necessary it is well to investigate the feasibility of installing small units at the particular locations where softening is required, rather than to attempt to soften the entire supply, much of which may not need softening in any manner.

Vitrified clay tile is now being tested for use in the construction of water softeners.

Chemicals

Chemical solution pumps may be made of plastics. Reinforced concrete chemical storage bins may be used instead of the usual steel bins.

Chlorinators: Substitute materials will be required for chlorinators but, as yet, no substitute materials are available which do not require the same high priorities as do the materials now used, i.e., AA and A-1-a ratings. Few, if any, materials can be obtained with a lower rating.

Chlorine: For conveying chlorine solution, glass or plastic pipe may be used instead of the conventional rubber-lined types. "Lucite" is being tested for use on chlorinator feed lines.

Drainage Pipe

For large size drainage pipe, an all-wood culvert is now available. This pipe requires no steel bands, nails or metal reinforcing of any kind, yet laboratory tests show it to be strong.

Rubber Tires

Synthetic rubber is the only hope of a substitute for rubber, but this supply depends upon the performance of an industrial miracle. Much can be done, however, to conserve present rubber stock and to prevent premature failure, by following these simple driving rules:

1. Drive slower than 30 mph. and very slowly on rough roads.
2. Turn corners and curves at very moderate speeds.
3. Start and stop slowly, as if you were driving on something breakable.
4. Do not jam tires against curbs or other obstructions.
5. Keep tires inflated, as recommended by manufacturer; check at least once or better, two or three times, weekly.
6. Keep car in good mechanical condition; check for alignment, uneven brakes and other mechanical conditions that affect wear on tires.
7. Rotate positions of tires every 3,000 miles.
8. Do not overload tires.
9. Do not spin tires when stuck in mud or on ice.
10. Keep tires away from gasoline, oil, petroleum products and heat.
11. Match dual tires for outside diameter to carry load evenly.
12. Check all tires frequently to prevent growth of injuries which would make it impossible to repair or recap them.

Structural Work

Many wartime water supplies are of a temporary nature, permitting justifiable use of somewhat unproven materials and lower factors of safety in structural design. It is well to use brick, clay and gypsum board products

wherever possible. These industries are working at about 30 per cent capacity. This will help to conserve badly needed lumber stocks. Brick and tile may be used for temporary construction by using lime mortar, instead of cement mortar, to facilitate later dismantling.

The unit stress for steel design now must be 24,000 psi., which will save about 10 per cent of the total weight required. Another great saving in structural steel may be had through continuity in design and welding. Welded construction should be used instead of riveting. In steel trusses, steel tubing should be used instead of steel beams.

Walls of buildings should be constructed of wood or masonry. For reinforced concrete work, all openings should be of arched construction. For many uses, plain masonry should be considered. Wall and column footings should be designed without steel. Plywood girders should be used to carry heavy loads. Trusses are best constructed of wood, the design technique in this art having advanced quite rapidly during the past several years. Wood roof trusses with laminated top chords and laminated timber beams should be used to save cost and increase strength.

Reservoirs, settling tanks, etc., should be constructed at ground level with sloping sidewalls covered with plain concrete and roofed, where required, with wood timbers. Some, recently constructed, have used as little as 1½ in. of plain concrete for the lining.

Equipment

All equipment requirements should be kept to a minimum; in fact no equipment will now be furnished without full justification. Practically all automatic operating equipment involves the use of critical materials; therefore such devices should be eliminated in favor of manual control.

Metallizing: No water works executive today should overlook the great savings which may be accomplished with metallizing equipment, to keep existing equipment functioning in first class manner. This equipment will quickly pay for itself in materials, manpower and money saved.

Fire Protection

About the most satisfactory material for fighting incendiary fires is portland cement. For floor fires it is foolproof. It should be stored in covered kegs to keep it dry and fluffy.

War Camps

All public water supplies must have reserve capacity, for it is essential to maintain good service under all circumstances; but this is not true in the war camps, where unusual restrictions may be enforced in the event of an emergency. Therefore, in reading this paper, the design engineer or water works operator should draw a distinct line between use for army cantonments, munitions plants or similar construction intended for somewhat temporary use. Construction or maintenance of permanent water works, where maintenance costs are of prime importance, must be more permanent.

Engineering

In times like these, new standards for construction and maintenance must be adopted. This is not easy, for present design standards are the result of millions of years of combined individual experience, which have met the

laws of economics and produced efficiency and permanency. In the past, many jobs have been put through on the basis of money, men and materials; but now the greatest need is for engineering and materials, because in many instances men and money are available if the job can be engineered to utilize the materials available. In meeting design and maintenance problems with a minimum of critical materials, it is essential to secure the most competent engineering service and experience available. During the war, many construction and maintenance steps must be taken which are not in accord with demonstrated standard practice.

Standardization: A real effort is being made by government officials to standardize many water works products, but, to date, this effort seems to be causing much confusion, the criticism being that such a step requires new production machinery not now available.

Manpower

Most water works provide some jobs which may be efficiently performed by elderly men; also they have many other jobs which may be efficiently performed by women. These two sources of supply should be studied when it becomes difficult to secure adequate help of the type usually employed. Manpower is a critical material during wartime. Most water works cannot meet the rising wages which industry is offering. They cannot readily secure water rate increases. It is not uncommon to hear of wages of upwards of $500 per month in industry to men who have received only a few months of training.

One answer to this problem, of course, is to eliminate all lost time due to accidents by fostering training in this subject. Manpower is not available to replace employees unable to work because of industrial accidents. Accident-prevention conferences should be held for all employees. The excuse that the necessary ability to conduct such conferences is lacking no longer should be given credit, for there is now available much fine literature on this subject. Getting employees to "Think Safety" actually eliminates accidents. There has long been room for much improvement in this subject in water works.

Deferred Construction

Because this is war, all materials are "critical materials," even though they may be plentiful, since they require manpower to produce. Every water works should defer all construction possible until after the war; therefore, substitute materials should be largely confined to necessary maintenance materials. It is believed that very few water works have made any attempt to carry on construction programs which could be deferred until after the war. Some have been doing some regular construction with out-of-stock materials, but this use is now curtailed and must receive a priority if the cost of work exceeds $1,500, a ruling on which no one should have complaint. No water works has the right to ask for any critical materials unless their use is vital to the health of the community in maintaining a water supply. It is not a radical thought to adopt the slogan: "Do not build today what can be postponed until tomorrow."

Maintenance

If water works men will use a little imagination and carefully analyze each situation, they will find that many

emergencies do not or will not exist, especially if they concern the use of vital materials. The rule should be: "No construction unless it must maintain vital service." Even in maintenance, imagination and some research will generally provide a way to secure satisfactory service without the necessity of utilizing critical materials or, at least, with reduced requirements. Many maintenance jobs should be deferred even if some risk is involved.

Conclusions

Now, as never before, the exercise of common sense and ingenuity is required on the part of designers and operators. The individual instances are so numerous and varied that detailed description is futile. Until the war is over, the four main standby materials —cement, sand, masonry and lumber— should be considered for each and every materials requirement, except as necessity dictates. So far the priorities board has been quite lenient with water works in the use of critical materials, where engineering integrity demanded such use; but, in other cases, substitute materials must be used to achieve the end. If the proper spirit exists, substitute materials may be utilized quite extensively. Adapting a new material to a given use requires ingenuity and determination. If failure occurs then by all means the cause should be established. Clear thinking, pooling of ideas and a willingness to pioneer may lead to many worthwhile practices heretofore unthought of.

The conservation of critical materials should be a whole-hearted voluntary proposition on the part of each water works; and care should be exercised to use only the minimum amount of those absolutely essential. There is little doubt but that many of the so-called substitute materials of today will be considered technically superior after they have been given full trial.

During the war, low pressures and poor service must be endured—even the most urgent construction will be difficult, if not impossible, to secure. Many maintenance and reconstruction problems must be deferred. Where the management set-up is favorable, certain definite sums should be set aside each year during the war, to meet the construction necessities which must be accomplished immediately after the war; but during the war most work will necessarily be limited to accomplishing the necessary engineering studies.

Many water works men have contributed their ideas and knowledge to the preparation of this paper. Space does not permit listing their names, but the author wishes here to acknowledge their invaluable assistance.

Applications of Metallizing in Water Works Practice

By J. S. Stevens

IT HAS been left for a national emergency such as the present one to bring us to a full realization of the necessity for conserving all of our resources. As we look back at our former methods, we find that the majority of us have used materials profligately, replacing slightly worn or mismachined parts with new parts and throwing the worn parts on the scrap heap. Of course, this has added to the nation's stockpile of scrap material, but it is not only the material that was wasted. There are precious manhours lying unseen in our scrap piles—manhours that the nation can ill afford to lose. Modern warfare, with its insatiable appetite for materials and more materials, every pound of which requires manhours to put it into the hands of our fighting forces, leaves no reserve of material and labor to be used for the replacement of equipment that could, with a little care, protection and ingenuity, be retained in service.

Construction equipment for our camps and bases at home and abroad, airplanes, tanks, ordnance and victory fleets are all hungrily absorbing, at a rate never before known, the materials, which, in peacetime, would be a superabundance for all needs. But, with ships and cargoes being sent to the bottom of the seas, with airplanes, tanks and guns being destroyed by the hundreds, with shells, bombs and torpedoes exploding in all parts of the world, the small amount of material remaining for home consumption must be conserved to the last pound, lest we find ourselves unable to carry on, on the home front. We must establish new values in regard to salvable parts and equipment and exert all means possible to retard the loss of materials by waste and corrosion.

Corrosion has long been one of the worst enemies of water supply systems. Millions of dollars have been spent, thousands of experiments have been made and untold quantities of steel have been sacrificed in the fight to conquer the rust problem.

Locations where steel is alternately exposed to water and air are, of course, the chief offenders, and many paints, asphalts and other coatings have been tried in the hope of attaining a permanent seal against oxidation. Some of these coatings have been more or less successful and have protected the metal for, possibly, several years, but the certainty is always present of having to remove equipment from service, periodically, for renewal of the coating. Zinc, with its action of forming its own protective coating of oxide, has long

A paper presented on October 29, 1942, at the California Section Meeting, Oakland, Calif., by J. S. Stevens, Supt. of Yards & Shops, East Bay Munic. Utility Dist., Oakland, Calif.

been a favored coating where the size of the object was suitable for dip-galvanizing. Zinc also holds the advantage of being near the ferrous metals in the galvanic series, thus minimizing the loss of coating metal by galvanic action.

Metallizing Protection

It remained for metallizing, i.e., metal spraying, however, to open the way to the coating of objects, regardless of size or location, with any desired metal. Some thirty years ago, this process of applying metal coatings by spraying was developed. For a number of years after its inception, this process was held in more or less ill-repute because of the uncertain bond between the sprayed metal and the surface being covered. This fault was due partly to the uncertain quality of metal wire used and partly to the mechanical shortcomings of the spray gun, but the most frequent cause of failure was the improper preparation of the surface to be covered.

During the past ten years, however, the mechanical development of the applicator and a better understanding of the care necessary in preparing a surface, have resulted in a process that occupies an important position in the present program of conserving vital materials, and one that will remain after this emergency to effect economies never before considered. With careful surface preparation, in conformity with established practices, proper selection of the coating metal and ordinary care in applying the sprayed metal, a surface protection may now be obtained that will solve many water department problems.

The process consists, essentially, of passing a wire of the desired metal through a flame and driving the resulting molten metal by air blast, in the form of a finely divided spray, onto a previously prepared surface. This is accomplished in one general way by the various metal-spraying guns on the market, i.e., feeding the wire by air-operated turbine and knurled feed rolls through a special nozzle and mixing chamber, where it is melted in an oxyacetylene flame and atomized by the air that carries it to the work.

The equipment and materials needed for this work consist of: an adequate supply of dry, clean compressed air; sand-blasting facilities; the spray gun, which is self-contained and is small enough and light enough to be operated with one hand; oxygen and acetylene tanks and the necessary hoses; a reel to handle the coil of wire being used; and, for lathe work, the lathe and preparing tool.

Aluminum, babbit, brass, bronze, lead, monel metal, nickel, iron, steel, stainless steel, tin, zinc and, in fact, any metal that can be obtained in wire form, lends itself to the process of spray coating; so, from this list, the coating which best fits the particular problem at hand may be selected.

Role of Surface Preparation

The limitations of the process must, however, be kept in mind. Sprayed metal is, in fact, cast metal and has practically no tensile strength; therefore, it should not be used where it might be subjected to tensile strain. It must also be realized that the bond between the sprayed coating and the work is purely mechanical, there being no heat, welding or forging action at the point of union. The bonding action is accomplished by the minute particles of sprayed metal dovetailing or keying themselves into the irregular pits or grooves of the prepared surface. It is evident, therefore, that this sur-

face should bear cavities or serrations that will permit of such dovetailing.

On flat work, it has been found that blasting with a sharp sand or steel or carborundum grit will give a satisfactory surface, while with cylindrical surfaces that can be handled in a lathe or rotated in their own mountings, it is the practice to turn U-bottomed threads or grooves on the work and mushroom the tops of those threads, thus forming a dovetail into which the sprayed metal can lock.

Any oil or grease, even that from clean hands or from the overnight oxidation of newly cleaned surfaces, will impair the binding ability of the spray, so it is imperative that care be exercised in handling the work between the time of preparing the surface and the spraying operation and that only as much work be prepared as can be coated before oxidation begins.

Metallizing has become recognized as an economical method of corrosion-proofing metal surfaces in all branches of industry and for all types of objects, ranging in size from small items that can be sprayed in a tumbling barrel to hulls of boats, structural steel work and large tanks that must be prepared and sprayed in the field. These diverse applications present their individual problems of surface preparation and procedure in spraying. In cases where the blasting material can be recovered and used repeatedly, steel or carborundum grit should be used, as it leaves an ideally rough surface and, notwithstanding the fact that its cost is about triple that of the best sand, its longer life makes it more economical to use. On work that does not permit of material recovery, a clean, sharp sand may be used. Dull or worn out sand and grit or steel shot will, possibly, clean the surface, but they leave no pits into which the sprayed metal can key.

Coating of Wash Water Troughs

The major project undertaken by the East Bay Municipal Utility District to date has been the zinc coating of 64 wash water troughs for the Upper San Leandro Filter Plant. These troughs, had, in the past, been coated with various paints, asphalts and rust preventatives, but each had begun to fail in spots after a few years, allowing deep pits to form. Due to the failure of these previous coatings and the anticipated difficulty of their removal, it was considered advisable to dismantle the troughs and bring them into the shop for cleaning and spraying. This was done in the late winter months when the demand on the filter plant was light, one filter at a time being taken out of service.

The troughs were of $\frac{3}{16}$-in. steel, having a U-shaped cross-section 15 in. wide and $13\frac{1}{2}$ in. deep, with one end closed and a reinforcing angle along each inside edge. Due to their length, $14\frac{1}{2}$ ft., it was necessary to build a temporary plywood extension to the sandblast cabinet.

Some of the former coatings, although destroyed in spots, were very difficult to remove, much chipping, burning and scraping being necessary before they were ready for blasting. The blasting was done with No. 40 steel grit, which resulted in a thoroughly roughened surface. Some difficulty was experienced in cleaning the underside of the reinforcing angles, until a flexible extension of 1-in. air hose was made for the nozzle end of the blast hose.

After thorough blasting and inspection, which often required return to the sand-blast cabinet for further clean-

ing, a coating of 0.010 in. of electrolytic zinc was applied. This was sprayed on in four separate passes, alternately transverse and longitudinal, to eliminate any thin areas or "holidays." The zinc wire for each layer was carefully weighed and, after a little experience, the operator was able to regulate his speed of application so that the proper amount of zinc went into each coating. A more accurate check on the thickness of metal deposited would be possible by the use of an electric thickness gage, by means of which the thickness of any nonmagnetic coating on iron or steel can be accurately determined.

Although the dust from sprayed zinc is very low on the scale of hazardous dusts, air-line respirators were furnished the operators to decrease the discomfort caused by breathing the dust.

The total cost of zinc spraying these 64 troughs was $4,432.40, or $69.25 each. This figure includes the cost of everything connected with the project —dismantling the troughs, transporting them to and from the filter plant, cleaning, blasting, spraying and replacing—as well as the cost of all of the materials required in the operation.

Although these troughs have not been in operation long enough since metallizing to make any estimate of the life of the coating, it is safe to assume, from the experience of others, that corrosion troubles have been relegated to the very distant future.

Other Applications

Some difficulty had been experienced with heavy scale dropping under the leaves of sluice gates at the San Pablo Filter Plant, preventing the gates from closing and scoring the bronze seats. At the time of overhauling these gates, they, together with the steel operating rods, were sprayed with 0.006 in. of zinc. Hydraulic gate operating manifolds were also zinc-coated to eliminate any rust that might find its way into the four-way cocks and score the seats.

Another application of metallizing has been the application of about 0.005 in. of aluminum to the exhaust manifolds and mufflers of the District's portable air compressors. It has been found that this coating withstands the heat of operation very well and prevents the usual incrustation of rust.

There are, in fact, innumerable possibilities in and about a water distribution system of using metallizing for solution of the corrosion problem. While first cost of application may seem high, the life of a well applied coating will more than compensate for that higher cost in comparison to the more frequent applications necessary with cheaper materials and the shutdowns necessitated by their use.

Tanks, tank floats, gages and ladders; reservoir gages, grizzlies and gates; water-wheel runners; outdoor signs, fences, railings and gates all offer a field into which it is planned to extend the use of metallizing. In renewing worn surfaces, also, metallizing is performing a great service toward the conservation of vital materials for the war effort and toward keeping in service equipment for which it might not be possible to obtain replacement parts. Even after the present emergency, those who have experienced the savings of metallizing over replacement of worn parts will never go back to their former wasteful methods.

At the East Bay Municipal Utility District the newly purchased metal spraying equipment has been kept busy

a large percentage of the time in renewing the wearing surfaces of shafts of various kinds. Pump impeller shafts, transmission shafts and roller pins of trenching machines and tractor and crane parts have all been built up to original dimensions with appropriate metals. Occasionally, when conditions permit, the worn bushing is reamed out and the shaft is built up to that larger dimension, thus saving both shaft and bushing.

Savings Obtained

The greatest individual saving has been obtained in building up the $2\frac{11}{16}$-in. diameter shafts used on trenching machines for main transmission drive. The bucket-line sprockets are always very difficult to remove, the shaft and sprocket hub usually being torn when pressed off. In this case, there is saved the cost of removal of the sprockets and the attendant repair of the hubs, as well as the cost of a new shaft, which at present is $58. The remaining cost is that for about ten hours labor of preparing, spraying and machining and that of a few pounds of wire.

In preparing shafts to receive sprayed metal, any one of several methods may be used. In the case of large diameters, such as large rolls, grit blasting roughens the surface sufficiently to form a mechanical bond. On bearing areas, however, additional keying means should be provided. The method preferred and being used by the District is briefly as follows:

The shaft is turned down to a diameter enough smaller than that of the desired finished diameter to leave a thickness of from 0.010 to 0.060 in. of sprayed metal after finishing, depending upon the diameter of the shaft and the expected wear in service. Below this smaller diameter, threads or grooves are cut, with a round pointed tool, about 0.045 in. wide, leaving ridges about $\frac{1}{64}$ in. wide between them. These ridges are then roughened and flattened by means of a preparing tool, similar to a knurling tool, which is mounted in the lathe tool post and run back and forth over them. This results in a dovetail groove in which the sprayed metal can form a key. The ends of the turned section are undercut at a 20-deg. angle to protect the edge of the sprayed metal. The spray gun is then mounted in the tool post with the nozzle about 6 in. from the work and the metal is sprayed on in thin layers until the desired rough diameter has been attained.

Sprayed metal is particularly suitable for bearing surfaces, as its porosity traps a partial film of lubricant, which, under test, has been found to decrease greatly the coefficient of friction and to increase the load at which bearing seizure takes place. This assures longer life from the renewed bearing surface than from the original metal and has led some manufacturers to apply sprayed metal to bearing surfaces in new machinery.

The District is using a fairly low carbon steel wire in spraying low-speed bearing surfaces, due to its machinability and the lack of grinding equipment which is necessary with the harder steels. On pump impeller shafts Tobin bronze is used for building up bronze sleeves and stainless steel is used at packing gland sections.

It is anticipated that other uses for metallizing will present themselves from time to time and it is felt that a great deal is being accomplished toward the reduction of maintenance costs, shutdown time and the waste of essential materials.

A Superintendent's Nightmare

By M'Kean Maffitt

It was the night before Christmas, and all through the house,
Not a creature was stirring, not even a mouse;
Bill Piatt and his crew came tumbling into town
And hell broke loose with a thundering sound!

Thus ended 1939 and began 1940. Peace and quiet, slow moving operations and general comfort passed out of the picture and rush became the order of the day. The lazy, peaceful days were done. Men came to town in droves and hootch flowed freely. Drunken drivers crashed hydrants for nothing better to hit. Sleeping quarters were at a premium and the pumpage rate began to climb. Contractors followed the engineers, vacant space was gobbled up, supplies were requisitioned—and then the storm. Stores, homes, rooms, vacant buildings, got new tenants and the streets were filled with men on their way to the bonanza. They took all of the available space and then some. The hotels, restaurants, boarding houses and private homes were filled with the comings and goings of workers, engineers, salesmen, non-workers and hangers-on. There were men and still more men. Women were in the rush; the call of the wild was too much. Where once had been virtue and modesty, there were now brazen faced ribaldry and libertinism.

Then came the flood, or so we thought. Laborers, mechanics, supplymen, electricians, pipe fitters, carpenters, masons and roustabouts galore. Trucks, jallopies, model T's, and any other thing on wheels. Farmers left their fields, fishermen their nets; men left their homes, and even the women flocked to Camp Davis, to the bonanza where money was the principal thing afloat on a sea of turbid hurly-burly. Work was done, or not done, according to each person's desire. The camp had to be built now, not tomorrow because tomorrow is too far in the future. As an example of what had to be done Yesterday, and not today an engineer came to my office with the statement that he wanted an estimate on the costs of building a water system and sewage plant for a town of

A paper presented on November 4, 1942, at the North Carolina Section Meeting, Durham, N.C., by M'Kean Maffitt, Supt., Water Dept., Wilmington, N.C.

20,000 men. Where the water was to be obtained; how it was to be purified, if purified at all; how the sewage was to be handled; where the plant was to be built—were all questions that could not be answered because of military necessities. "Just give me an estimate on the costs involved because I have to have the estimate in Washington by 4:00 P.M. this date, and it is now 1:30 P.M.—SO GET GOING!" was his insistent cry. All of the information that I could obtain was that there was to be an allowance of 100 gpd. per man, or a total of 2 mgd. How much would it cost?

Men continued to flock to town. They slept in hotel lobbies, restaurants, alleys, anywhere—some even went to jail so that they could have a place to rest their bodies. Some did not sleep, they walked the streets all night and slept on their shovels next day.

Traffic took an upward turn, the pumpage followed it, ran neck and neck and then passed it. The sale of hootch turned skyward and drunken driving was the order of the day. Telephone poles, bridge abutments, fire hydrants or other immovable objects became their targets. Hydrants were moved without benefit of supervision—flooding streets and covering valve boxes with oceans of water and beaches of newly washed sands. Valve measurements that had been based upon hydrants were of no value because the hydrant was no more. Search for valves had to be made by feeling along the pavement. No matter that the water was from inches to feet in depth. We crawled about in the flood, cursing our luck, while the onlookers made merry. Bets were placed as to who would drown first.

Things began to quiet down and peace and comfort seemed again to be

on the way when in stepped the Federal Government and bought, borrowed, begged or took all of the available space and began to build defense houses. No matter that there were no water or sewer facilities available, they could come later. Houses, more houses, and still more houses, not at Camp Davis 30 miles away, but right in our midst. Houses, houses here, houses there, and still more houses! Houses for Non-Coms, houses for Officers and houses for laborers—just so they were houses. General contractors started with bulldozers, shovels, trucks and men to build the houses. The time limits were set at ninety days and the storm broke. The southern side of the City looked as if the gold rush had passed through, and indeed it was passing—gold was the cheapest thing we had. Bulldozers plowed up what stuff we had. Shovels took the little

the bulldozers missed. Ditches ran from here to there with no declared intent and pipe workers placed pipe therein, be it right or wrong. Pipe and more pipe was scattered throughout the land. Building materials soared to unknown heights both in price and piles. Men swarmed over the face of the land like locusts swarming over the Good Earth. There was but one theme song, "Get the houses built, get the homes open, get sleeping quarters." Never mind the maps, they can come later; (in parenthesis, I may say that until today the maps have not come!) Get the houses built; never mind the materials. Men are coming, and more men behind those men.

But I was mistaken, there was another theme song, a song sung by the workers, it was, "Lay down your shovel in the old graveyard and loaf, loaf, loaf." Houses sprang up over night, sewers crawled into the ground —at least they must have crawled— they are so out of line. Water mains were fastened to the tails of rooters, and the rooters were started from here and went to there, unless the pipe gave out in the meantime. Water main plans that passed through my office were sent to Washington for approval; but there they were revised, and such revisions they were. Landscape architects must have been in charge. Mains are minus valves, streets run hither and yon with no system of numbering available, valves may be there but they can not be found. Manholes are there but like man's hopes they are not visible from the surface. Standardization was forgotten; hydrants are of any make with various sized operating nuts and threads. Valves were bought from those who could deliver, no matter the design and workmanship. Their make is now a dead letter. All that was necessary was to get the water on, to get the houses built, to finish the contract in the specified time. Inspectors may have been plentiful, though some had never seen a water main before and knew not the meaning of grade and alignment. When the foreman said it was O.K. then that was O.K. He should have known, he had done that kind of work for years and years; and now we have the bag to hold.

But that was but the beginning of our troubles. Mr. Priorities, alike unto Minerva, was born out of the whole cloth. A cloth thick enough to blanket everything. OPM, SPAB, DAMN, BVD, RSVP, and many other museum pieces passed in review, all the while other parts of the city grew and grew. The pumpage ran higher and higher until the index figure looked like my temperature. Promoters and developers built houses by the hundred, real estate people built them by the dozen, while individuals built in singles until my head rang with: "When will I get my water? Why can't I get some water? The tenant is in the back yard with his clothes in his car and wants to get in the house. When will the water connection be made?" Checks for installations fell in a shower on my desk. Orders for materials were sent here, there and everywhere. Priorities got mixed up with application numbers and we did not know for whom we did what. One, two, three, four, ten, fifty, a hundred a day they came, bringing checks and work orders, saying, "Put that main in for me yesterday, will you?" Citizens who had made apartments out of homes or who had built apartments over garages came in droves calling for water and more water and then some more water. Plans for installations and orders for work were piled high upon my desk. Insistent men had to wait until I could bore down and find the particular plan that was wanted. When found, I could give nothing better than a promise. The pumpage curve ceased to be a curve, it was a straight line pointed to the sky, the stratosphere or what have you. Pumps ran hot and I ran hotter. New motors were taboo, new pumps were in the raw materials stage. Brass, bronze and copper were added to the *verboten* list and what could we do?

During all this time our spirits got low and the river got lower. "'Taint going to rain no more" was the song. The water got salty and we caught the devil. Work day and night on extensions and night and day on dams and dikes and auxiliary plants and what not. The people arose in their mighty wrath and voted away our government and put in a new one. New surveys grew where other surveys had grown before. Engineers were selected to tell us what to do and where to go to get fresh water, all of which we had known before. Plans were made for new filtration works and contracts entered into for extensions.

Things began to look rosy, a lull in troubles, a letdown to where I only had a hydrant in one hand, a gate valve in the other, a pump in another and work orders in the other, with a chlo-

rinator under my arm. Then the M.D. got hold of me, tested my temperature, looked into my mouth, X-rayed me sitting, standing, lying (which was a natural condition), and rolling. He ordered a room at the hospital made ready at once, saying, "It will not be for long." Turning to me he said, "Git." I got. Then for six weeks my home was at room 118 James Walker Hospital. The night I went to the Hospital the family came out with tears in their eyes, mournful looks on their faces and flowers in their hands. The undertaker came by and sized me up and said that he was just looking for a friend. The cemetery keeper cleaned off the lot and generally everybody got ready for a big funeral, but I fooled them. The nurse was red headed and told me to "get the hell out of there" and I did. It took me six weeks to get straight and on my feet again.

While I was in the hospital the Assistant Superintendent died. He went on the job, looked over the work and lay down in peace and quiet never to move again. Things rocked along with all the help doing the best it could —which was mighty fine. Pipe was laid, pumps were set and motors installed and when I finally came back to the job everything looked natural, though slightly awry.

The new government took over and naturally had to study the situation before it could act. It ordered a start on the proposed extensions, a new survey approved the old. Bonds were voted and plans completed. The Federal government approved, allocated funds and said, "Get going." We thought we were on the way toward a solution of our troubles and it was not a salt solution. But one of those alphabets in Washington said, "No. You can have this and not that. You may do thusly but not thatly. You can have all the money you want and then some, but as for materials, there is an end to all things." The new filtration plant was authorized and the up-river extension approved, but no allocation for critical materials. Plans were revised and approved and work started and the contractor was at most, marking time.

Then the Japs hit Pearl Harbor and boy, did things pick up! Camp Davis was enlarged, anti-aircraft camps were set up and soldiers and sailors came to town. The shipyard was building ships and men were swarming all over the county. We had thought that we were in for a rest, but never a bit have we seen.

The draft hit the country like a tornado going through Florida. Men were taken away; boys went in the Navy; men went to the shipyards; camps sprang up all around; and traffic got dense, jammed, and had to be cut out just as logs are cut out of a river-jam. Streets had to be opened, widened, lowered and graded. Curbstops to be set back, poles, lines and hydrants moved out of the way. Manholes were covered, valve boxes torn up and meters carried away. More houses were built; more services installed—more pumpage and less materials available. With Camp Davis in front of us, Bluethenthal Airport to the right of us, the shipyard to the left of us and the devil behind us, we carried on. Government engineers came and looked us over and made recommendations. Committees came to town and said we must do this and not do that. Forms were sent us to fill out and return. Forms for this and forms for that. Electricity was rationed, tires were made taboo, gas was doled

out and more forms were sent from Washington, PD this and D.P. that. PD1-A and P-46 with end use symbols 12.10 and priorities X-3-189 and 4 Z's. You can do this if Sec. 3 of P-46—l. 3, revised to June 23, does not interfere with P-46, revised according to our letter of July 20, which refers to P-46 as of September 4. If the foundation wasn't up and the floor joists have been laid, then refer to form PD1-A copy of which is unattached, same is being revised to meet order PD-191 as shown in Sec. 3—iii—under H on form PD-200 etc., and so forth.

City Council, casting its eyes upon the future, ordered wells drilled so that in case it didn't rain any more we could at least get a bit of drinking water. Of course we could fight fires and flush sewers with salt water so we were not so bad off at that.

During the salt period last year it became the thing, the very social thing, to meet at the well. Gentlemen carrying buckets, jars, pails or any other type of container were standing in line talking to ladies whom they had never seen before, each waiting a chance to get a wee drap of drinkie. All the while the pumpage ran higher and higher and the pumps ran hotter and hotter and the priorities got tighter and tighter. It became *verboten* to do this, impossible to do that and criminal if you did anything. The forms got more and more involved and the operating force lost its mind while the Manpower Commission took more and more men. Women began to go in machine shops and wear pants and use spitting tobacco.

Calls came for scrap and then more scrap. We dug up old abandoned lines of pipe, rail and other such. We tore out old machinery, rebuilt it and placed it in service and made scrap of things that once had been thought to be of value. We turned in two tons of scrap brass and requested one little No. 35 crucible so that we could melt our own scrap and make a few items that had to be had. After many months of labor and patient waiting the crucible arrived and we are ready to start manufacturing.

Upon this scene of turmoil again arrived a government commission and 1,900 more houses were started. Another man approached the scene and wanted to know how much and how soon, for another five hundred houses. The shipyard is extending, Camp Davis is growing, Bluethenthal Airport is enlarging, Fort Fisher Camp is building up and the Marines have come to town, but I am damned if everything is well in hand!!

We tried to get the State of North Carolina to set up an emergency re-

pair stock pile of materials that could be sent hither and yon—so that emergencies could be met with materials out of the stock pile. The Governor said that there was no law and nothing could be done. We stocked a few items that we believed necessary, and now we are accused of hoarding. We are set to a dollar value of inventory equal to 1940. Because of immediately necessary extensions, 1940 inventory was almost nil.

We are now in the position of September Morn. We can not hold up our hands, yet we are commanded so to do. We know that we are in one hell of a mess and that if Mr. Hitler, the kind, gentle, loving -------- from Bershtesgaden, decides to make a Coventry of us, we have small chance of getting out with a whole hide.

Despite all the facts set forth above, that our supplies are running low, our pumps running hot, our pumpage running higher, our patience running short, our minds running slow, our manpower getting less; that the Japs and the Germans have not been whipped; despite these and many other things that could be better and may get a damn sight worse, we are carrying on, and will continue, in spite of hell, low water, Hitler, Hirohito, Musso, and any of the other so-called leaders—we will carry on to a finish, be that finish what it may.

Practical Aspects of Guarding Utility Properties

By George A. Hunt

ONE of the vexing problems imposed on public utility management by the war emergency has been the question of protection of plants and facilities against sabotage. Long before December 7, 1941, private industries engaged in producing material and equipment under the National Defense Emergency and the Lend-Lease programs had found it necessary to establish and maintain carefully planned guard systems to minimize the possibilities of sabotage. Such protective measures were in general required of both the manufacturers having defense contracts and the utilities serving them. After Pearl Harbor these industries, coming under the war program, had only to extend their guard systems and co-ordinate them with the requirements of the War Department and other federal agencies.

Municipal and private public utilities had at that time given very little consideration to the menace of co-ordinated and widespread sabotage, well organized and designed to cripple transportation, communication, electric power, gas and water supply facilities. As such planned sabotage is usually thought of as an enemy war measure the utilities considered that the Army was more or less responsible for their protection. The Office of Civilian Defense had been organized, however, and its local agencies under federal guidance had done some basic planning so that, at the outbreak of hostilities, protection, of a sort, was promptly established to cover some of the most vital public works. This initial guarding was accomplished by emergency forces furnished by the Army, by personnel recruited by local sheriffs and police, and even by volunteer groups from the American Legion and other such organizations. In the early hysteria, plans for guarding individual facilities ran the gamut from the mere locking up of buildings or the employment of a gateman to a completely fortified installation with barbed wire fences, sand-bagging, flood-lighting, bullet-proof machine gun towers, etc.

Many utilities promptly established human guard systems and there naturally was, and still is, a wide diversity of opinion in respect to the amount of guarding necessary and the nature of the protection that should be provided. The utilities have been offered much advice by dozens of bureaus, departments and public agencies, none of which, however, has had legal authority to dictate how an individual company should handle its guard problem. The conflict in recommendations and "or-

A paper presented on October 29, 1942, at the California Section Meeting, Oakland, Calif., by George A. Hunt, Guard Co-ordinator, Pacific Gas & Electric Co., San Francisco.

ders" from these agencies simply added to the confusion in the minds of management as to what really should be done.

Organization in California

These matters have now been fairly well ironed out and federal agencies operating under proper directives are supervising the internal security of communication, transportation, gas and electric utility systems. The water supply systems of California are under study by federal and state agencies for the purpose of establishing conservative and co-ordinated plans to safeguard the interests of the war program, the war industries and the general public, in respect to essential water supplies.

Matters relating to the protection of industries vital to the war program in California and of the utilities directly serving them have recently been made the responsibility of the Commanding General of the Ninth Service Command, administered by a Plant Inspection Section of the Internal Security District offices established on November 1, 1942, at Los Angeles and San Francisco. It seems that the program to be followed by this Internal Security Division is eventually to require that the guard forces of all plants assigned for protective surveys and inspections are to be organized and instructed as Auxiliary Military Police under an officer of the Army.

Planning for the protection of the scattered facilities of a modern utility must take into consideration the location and accessibility of each plant, the extent of the physical protection that can be provided and what human guards are necessary. Where human guards are needed a private guard system must be established with a complete program for the selection, training, uniforming and arming of guard personnel and for the method of their utilization and control.

The limitation in State Guard personnel will militate against the use of state troops for the protection of any private utility properties, and even state agencies, such as irrigation districts, must largely depend on private guards. It is the writer's opinion that in the final analysis, except for certain important railway and highway installations and perhaps some of the most important municipal projects such as the Los Angeles Water Collection and Transmission System and San Francisco's Hetch Hetchy system, the protection of important project works will of necessity be maintained by private guards, paid for by the companies or agencies owning the respective works. There is no doubt but that all such private guard units will, in the near future, be brought under the direct supervision of the Army in respect to the selection of the personnel, their training, uniforming and arming, and that their utilization will be directly controlled by the Army, especially where the utility is directly or indirectly engaged in the supply of service to war installations and war industries.

A State Guard plan for the protection of an installation such as a storage dam generally follows the Army "internal guard" policies. It will generally specify a barracks, a commensurate kitchen and mess hall, a recreation room and a relatively large complement of men to maintain a small number of guard stations or sentry posts. The state will charge the property owner for all or a portion of the cost of providing and maintaining the camp and feeding the personnel stationed there. In addition, the property

owner will be required to provide the essential transportation facilities. Due to the large number of men which it will be necessary to house and feed under such a plan, it is readily demonstrable that in spite of the higher wages paid to private guards, it will, in the long run, be less expensive for the property owner to provide his own guard system. This fact, together with the limitation on availability of state guard personnel and the necessity for minimizing the use of manpower, will require the establishment of private guard systems to protect most of the vital utility properties in California.

Protection by the Utility

The protection provided and paid for by the utility itself will necessarily differ from the type and scope of guarding that would be expected if federal or state forces were available. It will be impracticable for any agency to maintain a sufficient number of guards at any plant to resist an organized band of determined saboteurs. The best that can be done, and all that seems to be justifiable, is a "watchman" system to prevent damage to a plant or other important facility by one or two persons operating on their own initiative to do some local damage. A watchful armed guard will usually be able to prevent such a person or persons from taking the personal risk of a sabotage attempt.

The economic aspect, i.e., the relation between a company's net revenues and the amount of money it can afford to spend for protection, will generally govern the extent of protection that can be provided. This aspect will limit the number of structures or facilities to be guarded on an extensive system to those most essential to the maintenance of continuous service. All important structures, works and facilities of the utility must, therefore, be individually classified. Each unit should be given a relative priority in relation to the others of the system in respect to its importance and vulnerability from both a local and system-wide standpoint. In rating its various works the utility must give special weight to the units that are directly involved and essential in the supply of industry vital to the war effort. The importance of an individual unit will also depend on the alternate sources of supply that are available or that could economically be provided to fulfill the function of that unit in the event that it should be put out of service for any extended period of time.

Guard System Development

After such a classification, the facilities of the utility must be analyzed individually to determine the most effective and economic means for their protection. Consideration should be given first to permanent or semi-permanent physical measures that could be applied to deny access to the plant by any but authorized persons and to protect it against damage from nearby areas. Such physical protection should include fencing, locked gates, sandbagging, splinter-proof windows, clearing and illumination of adjacent areas, etc. Much of this type of protection has permanent plant value, and can be classified as capital account. It is therefore advantageous to expend considerable money and effort along this line to minimize the use of manpower and labor costs for human guards.

At plants where properly trained and alert company employees are on duty at all times the addition of such physical protection will often be sufficient. At more important plants, gatemen

may be added to augment the normal protection afforded by fencing and alert employees. At the most vital and vulnerable units it may be necessary to maintain one or more armed guards. A single guard station, operated on a 24-hour basis by three 8-hour shifts, requires 1.4 men per shift or 4.2 men on a 40-hour week basis. This fractional man is, of course, provided either by overtime, spread as uniformly as possible among the employees over a monthly period, by employing a part-time man, or by the use of a relief man to take up the slack and stand guard in any emergency when several guard stations are maintained at one or more local plants.

The corps of guards employed by a utility should comprise only carefully selected personnel, picked as far as practicable from company employees. Guards must be physically fit and intelligent and must have such mental capacity and personal attributes as to be fully fitted for this particular class of work. Guards should be uniformed, deputized and armed. They must be instructed individually in the performance of their general and specific duties, to the point where they can take care of themselves and intelligently handle any emergency that may arise. To accomplish this a guard manual should be prepared and each guard should be required to familiarize himself with its contents. Some classroom work and a periodic written questionnaire system are also desirable.

To supplement the protection afforded by armed guards at fixed stations and to cover the scattered facilities necessarily left unguarded, a large number of key employees should be deputized and charged with the duty of watching over company property in addition to their regular company work. Superintendents, foremen, linemen, groundmen, field representatives, lake tenders, canal agents, etc., are all natural "watchmen" or patrolmen, and when deputized and instructed are a valuable addition to a guard system.

The control of the guards should be separate and distinct from normal company operating routine. Although the responsibilities of plant operators and the guards detailed to protect a plant should be carefully co-ordinated, the responsibilities of each should be clearly defined. On a large system the immediate guard control and inspection system should be territorially decentralized. The chain of authority, heading in the managerial office, in respect to direct control of the guards should be rigidly followed. To be effective on their job and to justify their employment, the guards must be given explicit authority, which must be respected by all employees of the company from the president to the office boy.

Plans for Emergency Distribution System Repairs in San Francisco

By George W. Pracy

EMERGENCY wartime repairs to water systems must, of course, embrace every part of the collection works, transmission lines and distribution pipes, reservoirs and pumping stations; and, therefore, present a huge and complex problem. In San Francisco, as in most California cities, water works properties, fortunately, are scattered, so that the problem is not aggravated by the dangers of complete disruption of water service from a single blow. The San Francisco Water Department plans for defense of its system, therefore, are similar to those of most systems of the same size.

The city has been divided into twenty-two districts of various sizes—from less than 1 sq.mi. downtown to as much as 4 sq.mi. in the outer residential districts. At a headquarters located in each district are kept sufficient tools and material for emergency use; and a telephone is installed at each.

Six men are assigned to each district, two of whom—a gateman and a driver—are on call at all times outside of working hours. They must stay within hearing distance of the telephone. Each pair of men is on duty every third week.

One automobile, equipped with two sets of gate wrenches, is assigned to each district. This car is taken home every night by one of the men on duty and is kept until he returns to work. It is then used in the regular course of work by the regular driver, who delivers it each night to the stipulated place. In the event that Monday is a holiday the crew on duty carries over until Tuesday morning.

The 44 men of the 22 districts are notified by a system of chain telephone calls whenever an alert is sent out by the authorities. The man in each car picks up his associate and drives to their headquarters. At first these men were not called until the blackout, as there are comparatively many less blackouts than alerts, but the troubles of driving under blackout conditions were so great that the time of call was set ahead to the alert to permit the men to get to their assigned stations before the lights are extinguished.

To notify the 44 men takes 10 min. The driving time to headquarters averages 10 min., with a maximum of 20 min., if the driving is done before the blackout. If the men are in bed, an additional 5 or 6 min. must be allowed to permit them to dress.

A paper presented on October 30, 1942, at the California Section Meeting, Oakland, Calif., by George W. Pracy, Supt. of City Distr., Water Dept., San Francisco.

The cars are equipped with blackout lights and a large permit card issued by the police department. The men have armbands and identification cards. Each is provided with a gas mask.

The headquarters is also the gathering place for the demolition, decontamination, street and sewer repair and other similar service gangs and for any help needed to shut off large or recalcitrant valves. Upon these helpers, also, is placed the responsibility for cleaning the site of damage to permit work on the pipes.

Main Repair Procedure

It is not planned to make any permanent or semi-permanent repairs to the mains at night; but it is expected to shut down the sections in which there are broken mains and also to cut and plug the mains on both sides of the break with wooden plugs, to permit resumption of service for fire fighting purposes. The wooden plugs are an old emergency standby of the department, which have, in the past, been found entirely adequate. Care must be taken when driving them into the pipe, as they will split the pipe if driven too far. They are held in by means of a bar across the face, tied back by bolts, or wire in an emergency, to a clamp on the pipe. This device is satisfactory for use on mains up to 12 in. in size under 80 psi. pressure, but may slip at higher pressures. The larger mains, which are almost all steel, will have to be repaired as soon as possible, depending on their importance, and work may have to proceed continuously until they are back in service.

In addition to the group of 132 men who work from the district headquarters, two other groups are on assignment. The machine shop personnel of 12 men are on call, in groups of 4, every third night. They report to the shop, ready to take out and operate any piece of equipment that is needed. The other group called are men who report to civilian defense headquarters and the general office to take the messages that come in from the outside and relay them to the field headquarters. The general officers of the department are also on call one night in three. All men are notified by telephone on receipt of an alert and respond immediately.

The department has made arrangements with the contractors who are equipped to do water works construction and has prepared lists of all of their equipment and of the telephone numbers of the men who are to be called in the event that the equipment is needed in a hurry.

The department has been discussing the advisability of concentrating the gatemen at three locations rather than having them report to the 22 district headquarters. It is felt that any bombing will be concentrated in certain districts and that the outlying areas will not be damaged except by an occasional bomb. The reason for scattering the men about the city was the difficulty of traveling under blackout conditions. With better lights the grouping of the men would be more advisable and, even with the present lights, it may be the better method.

Problems Resulting From Plant Expansion and Minimum Standards for Water Plants in the Southwest

By H. J. Darcey

THE title of this discussion may suggest that some insurmountable problems have been created by the sudden development of new water systems and the expansion of existing water systems to meet the demands of war industries and military reservations. On the contrary, the engineering problems have not been extremely difficult. Because of the size and scope of the task and the rapidity with which the projects were constructed, however, the Army and civilian engineers, contractors and the members of the water works profession deserve a vote of commendation for their efforts, for their accomplishments definitely show that emergencies such as this can be handled by trained personnel.

Other problems, however, have caused considerable concern and delay, and some of them are worthy of mention. In the states comprising the Southwest Section of the A.W.W.A., the impact of the war industries and military reservations has directly affected some water systems and placed an overload on existing facilities during the completion of necessary additions. This problem was usually of short duration, being handled through the more efficient operation of the water systems. Where additions have been made to existing municipal facilities, the design factors have usually conformed to standard practice and are of a permanent nature, but in the development of new supplies which will serve only for the duration, minimum design factors and less permanent construction have been used. In no instance has any thought been given to the production of a water which would not be continually safe for domestic use.

One point which has caused some confusion and comment is the difference between the instructions released by the several U.S. Engineer Districts concerning the design data for water projects and, particularly for sewer projects. As there has been an overlapping of work within the different districts, it was only natural to expect controversies when two closely related projects were designed under entirely different directives. This has been a matter of administrative detail, but one which should be recognized so that the work of the various districts can be correlated.

The question of providing trained personnel to direct the operation of the recently constructed water plants

A paper presented on October 12, 1942, at the Southwest Section Meeting, Little Rock, Ark., by H. J. Darcey, Chief Engr. & Director, Bureau of Sanitation, Oklahoma State Health Dept., Oklahoma City, Okla.

has been one of the most perplexing problems. It was clearly demonstrated that the technical schools in the Southwest have not trained a sufficient number of persons and that there was not a sufficient number of persons available in existing water plants, who could be replaced by untrained individuals, to operate the increasing number of water utilities. This is indeed a serious situation, for where will replacement operators and superintendents come from in case of an emergency?

All states in the section have undertaken some kind of Mutual Aid Program as part of their State Civilian Defense Committee work. Inventories have been, or are being, made in these states of all material, equipment and personnel available in every community served by a water system. What value this information will have unless trained personnel is available to utilize the information is a serious consideration. A start has been made in one state, to train auxiliary workers on a state-wide basis. This is an excellent plan, but it is essential that each superintendent in charge of a water system undertake a training program within his own community so that emergency personnel will be available for service at a moment's notice. This need is becoming more and more important with the increasing restrictions placed upon the use of gasoline and tires.

Since the inception of the priorities system covering the purchase of supplies and equipment for use in water systems, there has been considerable apprehension regarding the future operations of water utilities. Part of the difficulty has been due to the number and complexity of forms required to be handled by the utilities and the uncertainty of securing needed equipment and materials. For a while, chlorine was difficult to obtain; now, however, a sufficient quantity is available for the needs of all water works systems. It is to be hoped that a simplified priorities system can also be developed for other materials and equipment.

It would be well to mention that some states have had unfortunate experiences with the Federal Works Program, due primarily to the delay in the approval or rejection of applications. It might be preferable to have all interested federal agencies review projects concurrently, then agree upon the action to be taken, advise the interested municipality or company of the decision which has been reached and thus eliminate the need for continual review of projects because of differences of opinion or misunderstanding between the agencies.

These remarks are not offered as a criticism of any agency or individual, but simply as a statement of facts which have been obtained from various sources, in the hope that a more constructive and co-ordinated program can be evolved for handling the supervision, operation and maintenance of water systems during the present emergency.

Wartime Administrative Problems of the Dallas City Water Works

By Homer A. Hunter

THE problems of water works operation in wartime are not far different from peacetime problems. They are only more acute and probably a little more difficult of solution. Wartime problems can probably be summarized in three words—men, money and materials. These same things are always important to water works operators, and just because the problems involved are harder to solve now, during the stress of the national emergency, they have seemed to be wartime problems. What might be an acceptable solution to a problem during wartime might not even be considered during peacetime.

Manpower Problems

During the past year the problem of obtaining and holding adequate and efficient manpower (and womanpower) has been troublesome. However, from now on, as the country becomes more and more geared to full war production and as the armed forces are further expanded, manpower troubles will increase tremendously. Where a year ago young and energetic men were in demand, the water works operator today is looking for the men over forty years of age who can carry on while the younger ones are away.

Private employment, at high rates of pay, is attracting many water works employees; and it is very easy for the mechanics and station operators to obtain private employment. Of course, most of the jobs to which they are going are only for the duration of the war and many will not profit materially by accepting a less stable but more lucrative job. In Dallas, as in most other cities and private institutions, a leave of absence is being granted to employees who volunteer or who are drafted into the nation's armed forces. The jobs of these men, if they are filled at all, are filled by temporary employees who, at the time they are employed, are made to understand fully that they are filling in for a man in the Army or Navy. Insofar as possible, the general practice in Dallas has been that the work of a man who enters the country's armed forces is distributed among remaining employees. This process has served more equally to distribute all the work as well as to take up the slack there was in the organization. But now, the work on every employee is so heavy that all who leave in the future will have to be replaced.

There is good reason now to substitute women for men wherever possible.

A paper presented on October 13, 1942, at the Southwest Section Meeting, Little Rock, Ark., by Homer A. Hunter, Supt., City Water Works, Dallas, Tex.

In the Dallas Water Works, several women are doing clerical jobs formerly held by men and two women have been employed as chemists, one for work at the water treatment plant and the other at the sewage treatment plant. These women are graduate chemists and have qualified for their positions under the city civil service regulations. They are both doing creditable jobs and are more than filling the jobs of the men who have gone. Women will, in the future, be called upon to do many jobs now held by men, and it is entirely possible that they can operate pumping stations and water and sewage treatment plants.

Salaries and wages paid to water works employees have been studied carefully and a considerable number of salary adjustments have been made in Dallas. This has been necessary in order to try to hold together enough trained personnel to keep things going. Recruiting by private industry and by federal agencies has become an aggravation, to say the least. Late in 1941, a blanket 7½ per cent increase in salary was given to all employees earning $125 per month or less, and no further blanket adjustments are contemplated at this time. At the same time that this bonus plan went into effect, all regularly employed operating and maintenance personnel, including laborers, were put on a regular monthly salary rather than retained on an hourly wage basis. This has served to stabilize and equalize wages throughout the year and the plan has been favorably received by the employees.

To assume the continued operation of all seven of the Dallas pumping stations, as well as the water and sewage treatment plants, it will probably be necessary to put several of the smaller pumping stations on a 12-hr. shift. All station operators now work 8-hr. shifts, but counting one day off each week, a station can be run with one-third less manpower on the longer shift. This plan will undoubtedly be found necessary in the very near future.

Practically every division of the Dallas Water Department is understaffed now, and other employees will be called up for military service as time goes on. Suitable replacements are not obtainable. It has seemed advisable to devise ways and means of reducing, if possible, the volume of work to fit the staff. This will conserve manpower and will also permit more economical operation of the department. The volume of work can be reduced considerably by initiating, for the duration of the war, a plan for the bi-monthly meter reading and billing of customer accounts. The Dallas Water Works serves approximately 80,000 accounts, 44 employees being required to do the job of meter reading, billing, bookkeeping and other related operations. If this work can be done on a two-month basis, instead of monthly, there will be an estimated saving of 17 employees' time, or about 39 per cent of all the people engaged in the Collecting and Accounting Division. Corresponding savings in paper for bills and envelopes and other materials will also be made if the plan is adopted.

The plan can be put into operation quite easily and with practically no disruption of office routine. The rate structure is not being changed. The city ordinance putting bi-monthly meter reading and billing into effect simply authorizes the department to assume that half the water used in a two-month period has been used in each of the months, the regular rates being applied on this basis. With this

operation, collection losses will be slightly increased, but not nearly in proportion with the savings to be made. Bi-monthly meter reading and billing of customer accounts were scheduled to go into effect in Dallas on November 1, 1942, and, so far as is known, this is the first city in the Southwest to adopt such a wartime policy. Other cities, most likely, will be forced to follow in the near future.

Protection of Plant

A very difficult problem for the water works administrator is the determination of the extent to which wartime protective measures should be carried. Bombing and sabotage protection and preparedness are extremely important during wartime. The administrator is very smart if he employs no guards and spends no money for preparedness—if nothing happens; but if the bombs begin to fall or if a saboteur gets loose in a plant that is not prepared, he is "out on a limb." If he does employ guards and makes other preparations to protect against bombing and sabotage and nothing happens, someone will want to know why he wasted so much money when it was not necessary. In Dallas, the Police Department has been assigned the duty of water plant protection, but all the special guards are paid by the Water Department, even though they work under supervision of the Police Department. Preparedness is absolutely essential and the administrator must choose a "middle of the road" position and make whatever provisions for protection against bombing and sabotage that seem justifiable under the situation as it exists in each individual city. He must realize at the outset that whatever he does will be wrong or right depending upon the point of view from which his decisions are analyzed.

In addition to plant and property protection, it is also necessary to organize emergency repair crews and to co-ordinate the emergency organization with the local civilian defense group and with emergency operations of other utilities. Emergency repair organizations for water and sewer systems can usually be formed from men already in the employ of the utility. Emergency repair materials should be dispersed and located strategically over the area served. Transportation should also be quickly available at the concentration points where the materials are located and where the repair crews assemble in time of trouble. In order that these repair crews may be able to operate in time of emergency with the proper degree of teamwork, it is necessary for them to be trained. In Dallas, this training involves having the crews make actual emergency repairs in the area to which they are assigned.

One of the biggest problems these days is that of preparing government reports and of keeping up with the changes in regulations. The volume of reports required these days is positively amazing—one often wonders what good purpose can ever be served by them. In Dallas alone, it is necessary for one man to spend his entire time on such work, and another man spends more than half of his time.

Materials Problems

Fortunately for Dallas, the Water Department has not been called upon to make any major extensions to serve war industries. All the war plants have been located where utilities were already available or were very near

the site. This has been accomplished by the co-operation of the local utilities with the U.S. Engineers' Office at the time site selection studies were being made. Many cities have been hard-pressed to extend water and sewer lines to serve war industries and defense housing. For such purposes, it is not difficult to obtain priority ratings, but that is only one step in the process. Getting the materials with the priority rating assigned often is more difficult than getting the rating. Then, when the materials arrive, the problem of labor to install them must be solved.

The water works operator who has all the manpower he requires, all the money he needs for his defense and preparedness program, the money to buy materials for necessary extensions to serve new industry, the money to pay employees to prepare required government reports, and all the materials necessary to keep his plants in operation is, to say the least, "the luckiest man in the world."

Relationship Between Small Town Water Supply and State Health Department

By Walter A. Reiman

THE relationship between the officials of a water supply and the representatives of a health department has been discussed on many and varied occasions. It is very likely that the conclusions on these occasions were as varied as the occasions themselves and that the position of the health department is still a puzzle to some water works men.

Before proceeding further in this discussion, it would be wise to say that each state health department is a unit within the respective state government and that it has the privilege of establishing its own policies. Therefore, the administration of the program within each of the states may vary. This is reasonable and desirable since the laws of one state may not compare in every detail with those of another, although the general principles or intent of the laws are comparable. Likewise, the manner of operation of a health department may differ from the department in another state, but the ultimate desire of each of the departments may be exactly the same.

In the development of a program of water supply improvements and control within the state, a health department must establish and abide by a policy that will provide the desired results. Broadly, there are three general policies a department may follow. One may be described as the endeavor of the health authorities to cloak themselves with all the necessary laws and to do nothing else than to apply any and all punitive measures if any water supply should violate any of the provisions of the statutes. A second policy may be described by saying that the health department is extremely indifferent to the conditions that exist in the public water supplies—that its interest extends only to the point where it hopes that nothing will happen. Neither of these two policies is very "healthy." The first, although it does, in a measure, fulfill the department's obligation to the water consumer, does not lend itself to a full appreciation of the water department's task. The second is absurd since no health authority would take this attitude toward a responsibility entrusted to him.

The third policy is one that has as its foundation the attitude of service to the municipality. This, it is believed, is the program that many state health departments have adopted. The small municipal water supply is often faced with the dual problem of providing the consumer with an adequate and safe

A paper presented on October 12, 1942, at the Southwest Section Meeting, Little Rock, Ark., by Walter A. Reiman, Chief San. Engr., Arkansas State Board of Health, Little Rock, Ark.

water and of meeting its debt retirement schedule. The production phase of the responsibility is often hampered by the limited assets available. Even under normal times, a municipal water plant is often financially unable to hire adequate or trained personnel or to retain the services of a consultant. Recently this has become more troublesome because of the more lucrative positions available in industries. This problem becomes particularly acute when the small supply has a treatment plant. Coagulation studies, methods of taste and odor control, chlorination, maintenance of facilities and equipment and many other troubles are the concern of the superintendent of a small water system, just as they worry the officials of a large plant.

The professional and technical personnel of the health departments is in a position to supply this need to the small water plant. The State Sanitary Engineer and his staff can be of valuable assistance to the superintendents in their operation and in solving the numerous difficulties that they face to satisfy the consumers—and their own conscience concerning the safety of the water. Health departments that have adopted this latter program have extended their services beyond the "advice state" and have endeavored to develop a technical staff actually to extend their assistance into the plant.

Health Department Services

For many years, all health departments have maintained bacteriological laboratories to which water departments could, periodically, send samples of water for examination. This service has been valuable not only to the health department but also to the municipality. The presence of coliform organisms in a supposedly potable water supply indicates contamination and reveals that there may have been carelessness or negligence in operation, or a deficiency which might not have been suspected and, thus, not found unless the laboratory tests revealed its presence. This is a service little appreciated. If the report of the water examination indicates contamination, it should mean more to the water works man than the necessity of clearing the system of this batch of water or providing a little more chlorine temporarily. The occurrence of coliform organisms should be taken as a warning that somewhere there has been an error of commission or omission. Subsequent samples that continue to show the presence of coliform organisms indicate that the difficulty has not been located or corrected. If samples periodically show the presence of the organisms, operation should be correlated with the sampling time to assist in determining inadequate treatment or control.

These remarks should not influence anyone to experiment with the phases of his water supply or treatment in the hope that some part of it may be eliminated. The comments were presented here only to give a clearer understanding of the usefulness of bacteriological examination of samples and a fuller appreciation of the services that are available.

Few water superintendents or operators have not at some time been troubled with taste and odor, coagulation, corrosion, softening or other similar problems. Many health departments have employed water chemists to assist in solving these problems. Their services are available for a study of any particular problem that will benefit the potability of the water delivered to the consumer.

Practically all health departments have co-operated in the inauguration of short schools or conferences within their respective states. This has been undertaken so that practicing water works men may have the opportunity to learn the latest developments in water supply practice. By these means it may be possible to increase efficiency of operation and to provide a better water at less expense.

These are a few of the services that health departments have endeavored to provide with their limited finances, inadequate trained personnel and shortage of equipment. The discussion has been presented from the viewpoint of a member of a health department and has briefly outlined what health authorities have been trying to do. Something should be said, too, of the superintendent and operator and their reactions to a program of this nature.

The Superintendent's Attitude

The superintendent may assume one of two attitudes. The first may be described as one of indifference or resentment because of the supposed interference by a health department in his business; the second, one of welcome for the assistance being made available to him. Much can be said of the superintendents and operators of water systems and their sincere efforts to accept and fulfill their responsibilities even though handicapped by lack of equipment, personnel and finances. The health departments know that the answer to the entire problem of water supply control rests within the hands of the superintendents and their assistants. Satisfactory control demands that superintendents and operators have complete charge of their systems. The peculiarities of the plant or the difficulties of treatment of a specific water supply can be fully appreciated only by those who work with it daily. The increasing number of requests for assistance and the amicable relationship that exists between the superintendents and health department representatives have created a feeling of mutual responsibility for the problems that confront them in the operation and maintenance of their systems.

Reasons for Service Policy

It might reasonably be asked why a health department should provide services that may have no bearing upon the potability of a water. The answer to this question can be found in any successful business firm. Increased efficiency and a better understanding of water treatment, regardless of its connection with potability, will result in a better and safer water. Consideration must be given to the fact that no one can be sure that dysentery, typhoid fever, cholera and gastroenteritis are the only water-borne diseases and that all the problems of water supply protection have been solved. It is not wise to be too confident that the ideal in water supply protection, which is the desire of every superintendent and operator—and of every public health official—has been, or ever will be, attained. Since the goal is the same, it is not surprising that those in charge of the utility and those charged with the public health of the state can meet upon a common ground with the friendliest of relationships.

This policy of assistance has been generally adopted by health departments and its benefits have more than repaid the efforts involved. It must not be forgotten, however, that a health department has mandatory or regula-

tory powers and that the public health is its sole responsibility. For this reason, the health department must supplement the co-operative program with one of strict supervision. Hesitancy to provide adequate treatment facilities or inexcusable negligence in operation can be corrected in many instances by only one method. This method may be violent and explosive but the seriousness of the situation may require it. It is doubtful if any health departments derive any more pleasure from such procedure than the officials of a water plant do in receiving it. Sometimes there is no alternative and the powers granted them by the laws of the state must be enforced.

The relationship between the water plant and the health department is difficult to express. It can possibly best be understood as a policy adopted by a governmental agency, empowered by law to obtain the desired results, that has tempered the aspect of enforcement with one of co-operation for the solution of a mutual problem. This policy will have only one result—a better respect for the responsibilities and problems of each of the parties concerned. Out of this will develop an understanding and a co-ordinated effort by health and water departments to rely upon each other for a mutual solution of the problems that confront the superintendents and operators of small water plants.

Emergency Experiences During Flash Floods

By Bernard S. Bush and M. J. Barrick

UNTIL the advent of flash floods in Pennsylvania in 1942, little more remained to be said about floods that might be of interest to a group of water works men. To water works men and State Health Department engineers located in northeastern and northcentral Pennsylvania, however, the recent flash floods presented certain problems which were not encountered in the type of floods that occurred in the Susquehanna River Valley in 1936 and 1940 and in the Ohio and Mississippi Valleys in 1937. In contrast, the flash floods of 1942 came as devastating walls of water without warning and with terrific velocities.

There were five such floods in Pennsylvania in 1942. First of these came on May 22 and 23 in the Luzerne-Lackawanna-Wayne County area, being generally termed the "Honesdale Flood." This occurred at the same time as another flood, in the Lehigh River Valley. The third flood occurred on July 18, in northcentral Pennsylvania, covering Potter, McKean, Elk and Cameron Counties; the fourth, on July 26, in Lancaster County; and the fifth, on August 9 and 10, in Lancaster, Chester, Delaware and Montgomery Counties.

Although all of these floods were of more or less serious proportions, the first two were by far the more serious, leaving in their wake a large death toll and widespread devastation which is almost indescribable. Similarly, only the first two played great havoc with water works, by leaving numerous communities without any water supply whatever for periods as long as twelve days.

In the Honesdale Flood alone, 66 highway bridges were wiped out at an estimated loss of three quarters of a million dollars. In the Lackawaxen Valley alone, over a stream distance of fifteen miles, 1,200 homes were damaged, 46 of which were demolished. In this same area, there was a death toll, by drowning, of 24 persons, the bodies of 2 having never been recovered.

Emergency Measures

Upon receipt of flood reports, the Governor's Emergency Disaster Committee promptly dispatched personnel from various state departments, as well as unlimited sanitation and medical supplies, to the afflicted areas, both personnel and supplies reaching the scenes of disaster before the complete recession of flood waters. At Hones-

A paper presented on October 9, 1942, at the Joint Meeting of the Four States and New Jersey Sections, Philadelphia, by Bernard S. Bush and M. J. Barrick, Dist. Engrs., Pennsylvania Dept. of Health.

dale, for example, a district engineer from the Department of Forests and Waters was designated as Flood Co-ordinator and the Health Department assigned personnel from the Bureaus of Health Conservation, Sanitary Engineering, and Laboratories. These men and women were called from all parts of the state and remained at the flood scene until all danger of an epidemic had passed. A mobile field laboratory, doing bacteriological work, in charge of a bacteriologist, as well as several engineers, remained on flood duty continuously from May 23 until the latter part of August.

The efforts of the Health Department engineers were directed first toward safeguarding emergency water supplies; next, to lend all possible assistance to water works officials in the restoration of public supplies; and, finally, to carry out general sanitation work for the prevention of the illnesses which could have resulted as an aftermath.

Defense Preparedness

During the last year, John H. Murdoch, State Water Co-ordinator for Pennsylvania, has labored diligently to perfect an organization through which co-operative arrangements could be established, whereby water companies in a large area, operating as a unit under a district chairman, would be in a position to cope with war disasters by making available, to damaged water works, materials, labor and equipment.* Great strides toward organization along these lines have been made, but, as has been the experience of district chairmen throughout the state, some few water works officials have been lax in co-operation. Consequently, when the test came, much assistance which might have been rendered by outside companies was not forthcoming due to unpreparedness. Without question, all of these companies were willing and anxious to help, but, because of their previous failure to co-operate wholeheartedly in the defense set-up as recommended by the statewide organization, immediate assistance was lacking. For example, if there had been on file inventories as suggested, much time could probably have been saved in effecting necessary emergency measures.

On Friday, May 22, the Honesdale Consolidated Water Co. was one of the best equipped, among the smaller companies, to combat a disaster, bombing or otherwise, but on the morning of May 23, practically every piece of this equipment had been rendered useless for the time being. During the morning of May 23, the flood struck, sparing nothing in its course, including the company's shop, warehouse, stock yard, garage and office. Much material was washed away and has not been recovered. Some of the material and equipment, such as, trucks, boats, motors, an air compressor and three very fine pieces of defense emergency apparatus, was either under water or under tons of débris.

Rainfall Data

At Honesdale the intensity of rainfall, the rapidity with which the water rose and the hour at which the peak occurred—2 o'clock Saturday morning—made it humanly impossible to save material things. An unprecedented rainfall, of cloudburst proportions, occurred during the 24 hours preceding 7 o'clock Saturday morning, May 23.

* Murdoch, John H., Jr. The Mutual Aid Plan at Work—Pennsylvania. Jour. A.W.W.A., **34**: 1186 (1942).

For several days previously, incessant rains had saturated the watersheds, thus creating abnormal and quick runoff conditions.

In a small area covering a part of Wayne County, with its upper extremity over the northern Lackawaxen Valley, a 7-in. rainfall was recorded. A fall of 6-in. occurred in a greater area covering the drainage basins of both the Lackawaxen and Dyberry Rivers, extending into the Lackawanna basin. Still larger areas received rainfalls of 5 and 4 in., all contributing to the aforementioned basins. Of interest is the fact that above the junction of the two rivers at Honesdale, the Lackawaxen has a shed of 94 sq.mi. and the Dyberry, 70 sq.mi. Above Hawley, at the junction of Middle Creek and the Lackawaxen Rivers, there is a drainage area of 289 sq.mi. Above Scranton, on the Lackawanna River, there is a drainage area of 603 sq.mi.

Honesdale

From early Saturday morning, May 23, to Sunday morning, Honesdale Borough was entirely without water and, to complicate matters for the water company as well as relief agencies, six out of seven bridges were demolished, making it impossible to travel from one part of town to another without covering a distance of 59 mi. Even boat crossings were not available until Sunday evening. Two of the bridges had supported large distribution mains, so that the town as well as the distribution system was divided into three separate parts.

It is easy to imagine the predicament of a water works operator responsible for service to a population of 10,000 with main transmission arteries, which had previously served three separate parts of town, destroyed for a distance of 100 ft. or more and with flood waters still raging through the courses in which the lines had to be relaid. This was true not only in the case of Honesdale, but in at least a dozen other communities following the floods.

It is of interest to note how recording gages vividly tell the story of successive breaks. The Venturi chart definitely indicated that the first two breaks occurred between 9:00 and 10:00 P.M. on May 22, both at Sellyville $2\frac{1}{2}$ mi. above Honesdale. Thereafter, all water was supplied from the distributing reservoir, which maintained pressure in town until river crossings collapsed. As each crossing was severed, the effect was indicated on the pressure chart, providing a complete record of the times at which breaks occurred and when the system was completely drained. In 14 hr., water supply was restored to the first part of Honesdale; in 48 hr., to the second; and in three days to the third. In stating that "service was restored," it should be pointed out that such service, in practically all cases, was temporary only. Invariably, it required from one to three months before restoration of normal service could be termed complete.

Hawley

At Hawley, a town of less than 2,000 population, where Middle Creek joins the Lackawaxen, a similar condition existed, although the Hawley Water Co. appeared more fortunate at the outset, the borough being served water from four springs and an impounding reservoir. The springs were not seriously damaged and temporary service to most consumers was restored as soon as emergency chlorination apparatus could be installed. Water from the impounding reservoir is carried 4

mi. through an 8-in. cast-iron transmission main and serves domestic water to the high sections, providing fire protection for the entire borough. A 1-mi. section of this line, paralleling, and partly laid in the bed of Middle Creek, was washed out. To date, less than 1,000 ft. has been reclaimed and it is not known whether the remainder is somewhere between Hawley and the Delaware Bay or under tons of débris in the immediate vicinity. Notwithstanding, it was necessary to acquire 4,000 ft. of new 8-in. cast-iron pipe to restore this supply. In this day and age, nothing short of such disaster would warrant a priority rating high enough to provide immediate delivery on this quantity of cast-iron pipe for such a small water company, but the required priority rating was obtained within two weeks after the flood, enabling prompt action.

Incidentally, due to previous difficulties, this disaster being almost the last straw, the entire mile was relocated to eliminate future chance of similar destruction.

Waymart

Waymart, a borough of 1,000 population, is situated along an ordinarily insignificant tributary of the Lackawaxen. This stream overflowed its banks and tore through a 300,000-gal. spring-fed reservoir, partially filling it with earth and rocks. First signs of difficulty were evidenced by highly turbid water in house taps. Shortly after, the water supply was cut off. Since the distribution system was not damaged, water from an auxiliary well was bypassed around the reservoir to the supply main. Normal chlorination facilities remained intact. Consequently, by means of flushing and increased chlorine application, sterilization of the distribution system was accomplished with comparative ease. Water from the drilled well furnished a safe domestic supply until the reservoir was cleaned and put into service 10 days later.

Northcentral Flood

Official compilations of rainfall data for the northcentral Pennsylvania flood area have not been released. There is one official reading, however, covering a 24-hour period of 8.5 in. at Coudersport in Potter County on the extreme upper reaches of the Allegheny River. The downpour first centered in this area and moved in a westerly direction, following somewhat the course of the Allegheny River, setting the stage for the unusual flood occurring in the Port Allegany area. Afterward, it apparently took a southwesterly course in diminishing intensity until it reached the proximity of Emporium.

In this flood area, which included Potter, McKean, Elk and Cameron Counties, major damage to water works was experienced at Galeton, Coudersport, Austin, Roulette, Port Allegany, Eldred, Driftwood, Emporium and Johnsonburg. Damage to the Austin and Port Allegany water works was similar to that at Honesdale, Hawley and parts of the Scranton-Spring Brook Water Service System.

Port Allegany

The Port Allegany Water Co. supplies approximately 2,000 people, from four sources—three gravity supplies served by upland reservoirs, and wells in the borough, from which water is pumped directly to the distribution system.

All three of the upland impounding basins, with a combined capacity of approximately 1 mil.gal., appeared to be filled with débris consisting largely of earth and rocks. In addition, supply mains from each were damaged in one or more places. Such damage amounted to anything from broken joints to completely washed out lines in sections of 100 ft. or more. Fortunately, the wells and pumping equipment escaped the flood. The picture there seemed encouraging at first, for the wells were intended to serve in just such an emergency, but it was discovered that water pumped into the system disappeared like melting snow in July, indicating many and perhaps serious breaks.

Pumping station capacity at Port Allegany is twice that of available water from the wells. Therefore, one of the outstanding emergency measures employed was to borrow 2,000 ft. of fire hose with which water was conveyed from a drilled well in an industrial plant. The hose was laid through private properties, across the main street to the pump station. It would have been a simple matter to connect this supply directly to a fire hydrant outside the plant, except that the quality of water from this flooded well was questionable. Since there was positive chlorination control over all water at the pumping station, consumers were served from this point. Temporary service was provided in this manner until eight days later, when one of the upland supplies was restored.

Austin

Austin, a borough of 1,000 population, experienced a repetition of its 1911 disaster, with extensive damage but much fewer losses of life. Upon first investigation, damage to this water works appeared to be less serious than at most others. Nevertheless, a series of difficulties was encountered resulting in depriving Austin of water for over a week. There were comparatively few major distribution system breaks, but services, severed when houses washed away, presented much difficulty. Because of the terrific damage to streets and the accumulation of débris, it was impossible to locate these breaks until after water was pumped into the system. The source of supply is a spring across the West Branch of Freemans Run discharging into an intake basin from which water is pumped through a 6-in. line to town. Oddly enough, this transmission line was not seriously damaged, suffering only one major break. A supporting bank at one end of the intake basin washed away, leaving the wall badly cracked and in a precarious state. The wall was temporarily braced, but leaked badly, requiring the construction of an emergency brick wall dividing the basin in half.

Sterilization Methods

In the several flooded areas the equipment used in sterilization of mains and distribution systems included trailer type chlorinator units, portable direct feed chlorinators and hypochlorinators. This special equipment was furnished through the courtesy of Wallace & Tiernan Co. and was delivered by its representatives who remained in the field to make the installations and to operate the equipment.

Hand pumps, feeding a hypochlorite solution to lines under pressure and apparatus feeding chlorine gas direct from tank to mains were also used.

This equipment was supplied through the courtesy of the Scranton-Spring Brook Water Service Co.

In addition to the foregoing, use was made of existing chlorination equipment and the common hypo barrel.

The procedure followed to render water safe for consumption in this emergency work was: (1) to sterilize contaminated sections and new pipelines as they were repaired or replaced; and (2) to insure treatment of water from the sources in order that a 0.2 ppm. or higher residual could be maintained throughout distribution systems. This treatment was found, upon bacteriological analysis, to produce a safe water.

In spite of the extensive damage to transmission and distribution pipe lines, Honesdale also had some good fortune. Due to the foresight and prompt action of the water company, loss of water was prevented immediately following the disaster, thus leaving large reserves to be turned in as soon as repairs were made. Likewise, pipeline arrangements were such that emergency chlorination was initiated with a minimum of difficulty after proper equipment became available. This was possible because all water served to Honesdale converges at a central point. Upon installation of a portable emergency chlorinator at this point, chlorine residuals throughout the system were controlled at will.

As a general procedure, where the systems received flood or suspected polluted water, chlorine doses were applied in sterilizing proportions, producing blood red residuals. In a few cases this was accomplished through the facilities at the sources; generally, however, it was necessary to confine sterilization procedure to sections of a system. In most of the work, the hypochlorite hand pump was used, the hypochlorite feeder being substituted where power was available.

Many smaller water works were supplied by springs, the water from which, in numerous cases, had not previously been treated. Most of these sources were contaminated by the unusual penetration of surface water. The mere matter of installing emergency chlorination was not so great a task, but it consumed precious time and labor was extremely scarce. At works where chlorination treatment was normal practice, increased dosages provided satisfactory disinfection.

In most instances, following the sterilization of new lines and contaminated parts of the system, a chlorine dose of 12 to 15 lb. per mil.gal. resulted in a 0.2 ppm. or higher residual throughout; but, in those systems which had never before been chlorinated, a different experience was encountered.

On one such small water works, serving approximately 200,000 gpd., chlorine was first applied at a rate of 18 lb. per mil.gal. Before any trace of residual could be obtained in the system, the dose had to be increased to 36 lb. per mil.gal. At this rate it required three days of flushing and bleeding dead ends before residuals were obtained throughout the system. This same rate was continued for one entire week before objectionable tastes appeared.

In still another instance, treatment was started at the rate of 18 lb. per mil.gal. and increased twice daily until, at the end of the third day, a rate of 76 lb. per mil.gal. was reached, giving a slight residual as water entered the distribution system. This point

was approximately 5 mi. distant from the source of application. To obtain residuals throughout town, it became necessary to install a hypochlorite feeder, as a booster, at the entrance of the distribution system.

No two floods are alike in their behavior and effect upon water works systems. No fixed method of attacking sterilization problems is applicable to all instances, but the remedy must suit the individual case.

Experience in these cases disclosed strong points and certain weaknesses in water works defense preparations and very specifically revealed the distinct advantages of having specially trained personnel to handle such emergencies.

This summer it was *flash floods*—next summer it might be *flash bombs*.

Discussion by *George R. Taylor.** The very excellent paper presented by Messrs. Bush and Barrick emphasizes the value of organization for emergency work. The fact that the Governor's Disaster Committee, the Red Cross, and other groups had been put on a war footing made it possible to get immediate action in the Honesdale Flood and elsewhere throughout the state. Much credit should be given to the authors and their assistants for their leadership in this work. In addition to restoring the water supplies and insuring their safety, action had to be taken on many other phases of restoration; and all this activity was complicated by the pressure of satisfying conflicting interests, which involved much mental strain as well as actual physical work.

The authors did not have time to describe the numerous expedients adopted to give temporary water supply, but there were many interesting ones, such as that of crossing streets with copper tubing tied to telegraph poles and trees.

The Scranton Weather Bureau Station is the only one in the area equipped with recording gages. At that point, two-thirds of the rainfall came between 5 and 7 P.M., May 22. Assuming the same intensity at Honesdale, a fall of between 4 and 5 in. is indicated for a two-hour period there. This would explain the terrific force of the flood.

From the authors' description of chlorination of flood water supplies the writer concludes that it is necessary to throw aside all preconceived ideas of proper chlorine dosages and go ahead pushing chlorine into the water until it actually appears in the distribution system. Treatment with 76 lb. per mil.gal. is heroic treatment, especially since the Galeton supply had no appreciable turbidity.

In spite of these flash floods, however, cases of typhoid fever have shown a decrease over previous years. Some of this result at least is due to the co-ordinated effort which characterized the flood relief work this year.

Damage and Repairs

The principal damage in the Scranton Division of the Scranton-Spring Brook Water Service Co. was at Olyphant and Elmhurst Reservoirs. At Olyphant Reservoir the 12-in. pipeline was broken in many places over a distance of 4,000 ft. It was possible to supply water from another reservoir in a few hours, but under reduced pressure. On the second day a chlo-

* Chemist, Scranton Div., Scranton-Spring Brook Water Service Co., Scranton, Pa.

rinator was set up on an unused reservoir nearby and normal pressure was thereby restored. The entire 4,000 ft. of transmission line was then relaid in a better location and sterilized with the reservoir chlorinator before being put back in service. The 30-in. pipeline from Elmhurst Reservoir was also damaged in several places. Seven families were without water, being supplied with 40-quart milk cans until the line was repaired.

Minor damage was also done to other dams but these involved no interruption in service. The estimated repair cost in the Scranton Division was $50,000.

The division's supplies are not filtered, so that turbid water was the rule for a week or more after the flood. Chlorine dosages were up to 20 lb. per mil.gal. in some cases to give satisfactory bacterial results. In one or two cases it has been necessary to continue this heavy dosage down to the present time.

One reason why it was possible to maintain service is that the Scranton Division, which supplies 25 miles of the Lackawanna Valley, has eighteen separate sources of supply. These sources are inter-connected so that it is possible to reroute water over long distances and thus maintain an adequate supply at all points.

Discussion by *Myles W. Edwards.* * In discussing the fine paper presented by Messrs. Bush and Barrick, the writer proposes to supplement the data they have presented with a more detailed review of the specific experiences of the Spring Brook Division of the Scranton-Spring Brook Water Service Co. in the "Honesdale Flood." The writer wishes, too, to compliment the authors, not only on their comprehensive survey of the situation encountered throughout the state, but on the work that they and their associates in the State Health Department did during the emergency. Without the utmost co-operation and consideration on the part of that department, the problem of the writer's company and other water works in the flooded area would have been much more serious.

In reviewing the situation, it should be emphasized that the flash flood was the result of the cumulative rainfall rather than that of a single day, May 22. The runoff from the watershed of Spring Brook during and following the flash flood caused disruption of utilities and railroads on a scale previously unknown in this locality. It would be impossible to describe the almost unbelievable destruction of highways and other property caused by this downpour.

Pipeline Damage

Upon the disruption of the transmission mains from the Spring Brook Intake Reservoir the following towns were without water: Moosic Boro, Duryea, Avoca and Pittston. The failure of the line from Watres Reservoir cut off service to Dupont, Inkerman, Sebastopol, Pittston Township and a few other hilly regions. The washout of a highway bridge carrying with it an 8-in. line from Stark Reservoir disrupted service in Old Forge and certain sections of South Scranton, thus affecting, in all, approximately 20,000 people.

A brief summary of pipeline damage is in order, though no attempt will

* Chemist, Spring Brook Div., Scranton-Spring Brook Water Service Co.

be made here to discuss all of the damage. Consideration will be given to the major repairs on large lines.

The 24-in. line from Spring Brook was washed out in three places, breaks occurring in two places.

The 30-in. line from Spring Brook was washed off piers, etc., in five places, breaks occurring in three places.

The 36-in. line from Watres was broken in the Spring Brook creek bed.

One 12-in. distribution main and one 8-in. distribution main were lost when two separate bridges washed out, carrying the lines with them.

One 16-in. line from Mill Creek Reservoir and one 8-in. distributing main on the Gardner's Creek system were broken because of washouts, but service was not interrupted on either of these systems.

The extent of the damage could not be determined until the water had receded, and this, of course, greatly delayed the start of repair work. The transmission lines damaged normally furnished 20 mgd. of the 50 mgd. total supplied.

Emergency Distribution Methods

The temporary re-routing of water from Campbell's Ledge, Huntsville and the Scranton system prevented another 10,000 people from being deprived of water. The inter-connection of this distribution system with other transmission systems made it possible to supply low pressure water to Pittston City and adjacent communities on and after the night of May 22. The failure to supply the highland regions of this area was due to the disruption of the transmission main from Watres Reservoir, which is entirely independent of the Spring Brook system, although originating on the same watershed. To relieve the critical situation rapidly developing from the lack of safe drinking water, distribution of a limited amount of safe water to approximately 3,000 families was begun by the company.

On the afternoon of May 24, a 2,500-gal. milk tank truck was obtained from a nearby transfer company, making possible the immediate distribution of drinking water to the affected area. This distribution was not suspended until June 1. This tank truck was exchanged at the end of 24 hr. for one of 4,000-gal. capacity. This delivery was augmented by two company trucks each carrying twenty 10-gal. milk cans of water.

Stations were established in numerous places throughout the affected area and a schedule, whereby each station was supplied at least once every 24 hr., was maintained. A short time before the trucks were due to arrive at their various stations, messengers were sent ahead to notify a few nearby residents of the impending arrival of the trucks and, regardless of the time of day or night, a large crowd of people, with every type of container imaginable, were present awaiting the water.

Water for this distribution was obtained from a fire hydrant in West Pittston Boro, being provided finished water from the Huntsville distribution system. Due to the use of a fire plug and hose to supply the tank and cans, however, it was thought best to rechlorinate the water. This was done by placing 1.0 oz. of hypochlorite in the bottom of the tank truck and depending on the velocity of the water from the hose to dissolve and mix it. By this method, the company was able to deliver a water with a residual chlorine content of from 0.30 to 0.50

ppm. The same procedure, using less hypochlorite, was followed in the chlorination of water in the milk cans.

Repair of 24-Inch Line

The Spring Brook transmission system consists of one 24-in. cast-iron line and one 30-in. cast-iron line, laid in parallel, adjacent to the highway which follows the stream bed. Because of fewer breaks in the 24-in. line, it was repaired first. The job, however, was hampered by the enormous amount of damage to the highways.

Upon completion of the emergency repairs to this line, a mobile gasoline-powered chlorinator was used to chlorinate 1¾ mi. of line. This machine had been made available through the courtesy of Wallace & Tiernan Co. and the equipment had been standing by ready for service for two days prior to the completion of the pipe repair.

The chlorination of the line began at 3:30 P.M., May 27, and was continued for 10 hr. While being chlorinated the water was flushed from the line for 4½ hr., satisfactory residuals being obtained after 2½ hr. of treatment. At 8:00 P.M. the water was turned into the distribution system, a "boil water notice" being issued by the company in conjunction with the State Health Department at that time. The notice remained in effect for 48 hr., until the samples taken were found to be negative for coliform organisms, making the precaution unnecessary.

At 1:30 A.M., it was found that the water had a chlorine residual in excess of 2.0 ppm. before reaching the tap used for the portable chlorinator so the use of the mobile chlorinator was discontinued. The point at which the chlorinator was operating was approximately 2 mi. below the permanent chlorination station which was also in service. In the 10 hr. of operation, the mobile unit treated approximately 6 mil.gal. of water with 115 lb. of chlorine, against a pressure of 60 psi. The speed with which it was possible to fill, treat and flush the line was the result of the use of the gas-powered vacuum chlorinator.

After restoration of service on the 24-in. line, 4,000 people still had no water supply.

On Monday, June 1, an attempt was made to put the 30-in. line back in service, chlorination of the pipeline, using the mobile unit, being started at that time. Under pressure, however, another series of breaks was discovered and the job had to be stopped. The line was finally completely repaired and chlorinated on August 5, but, due to further failure of the line on September 14, it was re-chlorinated on September 16.

Repair of 36-Inch Line From Watres

The break in the 36-in. line from Watres occurred about 500 yd. below the intake, at a point where the line crosses through Spring Brook creek and just above the chlorination station. In order to place this line in service, it was first necessary to find a temporary road into the location of the break, the regular road into the area having been destroyed by erosion. This difficulty was met by using an abandoned railroad bed for some distance, then following a narrow dirt road and finally striking off across country for approximately ¾ mi., using a diesel engine bulldozer to clear the way. It was necessary to construct a pipeline bridge across the stream, building it of timbers cut at the scene of the break and erected as soon as the

water level in the creek had been reduced to a workable depth. A temporary 16-in. cast-iron line was laid over the bridge and joined to the exposed ends of the 36-in. line by hastily devised reducers. The reducers were made by cutting openings in the centers of two 36-in. cast-iron plugs and brazing the spigot ends of short lengths of 16-in. pipe to them. The total length of this temporary line was 260 ft. The 36-in. line has since been relaid in the creek bed and operation at this point is again normal.

Routine chlorination at this point is carried out by the operation of a Wallace & Tiernan Manual Control Solution-Feed Vacuum chlorinator, capable of feeding from 25 to 150 lb. of chlorine per 24 hr. The operation of this chlorinator against a pressure of 60 psi. is accomplished by the use of three Ross pumps. Upon completion of the temporary line, the chlorinator was started and a residual of 1.5 ppm. maintained at the test tap. After the line was filled, the rate of chlorine feed was reduced to 75 lb. per 24 hr., treating approximately 6 mil.gal. of water and giving a test tap residual of 0.60 ppm., with a residual of 0.20 ppm. in the distribution system.

Emergency Chlorination Methods

The restoration of service on this transmission main completed the emergency work needed to supply water to all consumers. The repair of the 30-in. transmission line from Spring Brook was completed on August 7. The chlorination of this line was of prime importance due to the breaking of a sewer line in the stream bed adjacent to the first break in the transmission main and resultant contamination of the line with sewage.

Following the repair of this line, a section of pipe was left out so that a high velocity wash of the pipe could be used to remove small stones and débris which had been washed into the line. Two taps were made above the first break and two chlorine diffusers inserted. Two 100-lb. cylinders of chlorine were then tied to each diffuser and chlorine applied to the water as it was used to wash out the line. This process was repeated in clearing out the line below the open length, by sending water into the section from an inter-connecting gate with the 24-in. line. Upon replacing the length of pipe which had been removed for cleaning purposes, an 8-in. blowoff was opened at the end of the contaminated area, following which the water was slowly turned into the 30-in. line.

It was possible to keep the pressure in this line under 30 psi., thus permitting successful chlorination by the established direct feed method. Three hours after starting chlorination for the second time, a blood red residual—in fact a residual which precipitated the ortho-tolidine—was obtained. At this time, the blowoff was closed and the line allowed to stand with the super-chlorinated water for 12 hr. At 7:00 A.M. the blowing off of the water was started. Water with a residual of 0.20 ppm. was obtained 3½ hr. later and once again the blowoff was closed, all water entering this line having been previously chlorinated at the head of the transmission system by the regular facilities. Samples were taken and the line was not used until negative coliform results were obtained 48 hr. later. The water was finally approved for distribution on August 10. This chlorination job required a total of 99 lb. of chlorine.

Although this method of chlorinating broken lines has been very satisfactory, it must be apparent to all that it can be used only where the pressure against which the application is made is considerably less than that of the chlorine in the cylinders. It is not intended to suggest that the use of this method is preferable to a portable chlorinator, but it is known that, under proper conditions and handling, it will do the job and that the equipment required is relatively easy to assemble from parts usually on hand at most water companies.

The chlorination of these lines paid large dividends. Of the 69 samples taken by the company and many collected by the State Health Department, none showed the presence of coliform organisms. To substantiate the laboratory results obtained, it should be pointed out that there were no reported cases of illness due to waterborne organisms.

The work discussed here was carried out under the direct supervision of Rulison Evans, President, W. T. Barnes, Chief Engineer, and the writer, all of the Scranton-Spring Brook Water Service Co.; G. D. Norcom, Consulting Chemist and Sanitary Engineer; and L. D. Matter, Pennsylvania Department of Health.

Public Health Service Drinking Water Standards

UNITED STATES PUBLIC HEALTH SERVICE
Washington, D.C. September 25, 1942

ADOPTION

The Public Health Service hereby adopts the standards of purity for drinking water recommended by the Advisory Committee on Revision of the 1925 Drinking Water Standards, appointed by the Surgeon General in February 1941.

These Standards are adopted for use in the administration of the Interstate Quarantine Regulations as they relate to the drinking and culinary water supplied by common carriers in interstate commerce. The manual of recommended water sanitation practice [not included here; to be published in the February JOURNAL] is intended to serve as a guide to the reporting agency and not as a part of the official Standards which must be complied with to obtain certification of the water supply.

In the future common carriers will be required to furnish drinking and culinary water for passengers and crews in interstate traffic which will conform to these standards.

(S) THOMAS PARRAN
Surgeon General
United States Public Health Service

Approved: December 3, 1942
(S) WATSON B. MILLER
Acting Administrator
Federal Security Agency

Preface to the 1925 Edition

The preface of the 1925 Drinking Water Standards is presented below and represents the ideas and report of the Advisory Committee which assisted in the preparation of those Standards. This material is presented as an historical background upon which some of the findings of the present committee have been based.

In recommending the adoption of these standards the Advisory Committee submitted a report discussing the requirements as follows:

EDITOR'S NOTE: This document is reproduced here from the January 15, 1943, issue of *Public Health Reports* (vol. 58, no. 3), by permission of E. R. Coffey, Asst. Surgeon General, U.S. Public Health Service. The A.W.W.A. will not reprint the document, but reprints will be available from the Superintendent of Documents, Washington, D.C., by requesting Reprint No. 2440. The price will probably be 10 cents per copy.

REPORT OF THE ADVISORY COMMITTEE ON OFFICIAL WATER STANDARDS [1]

The task referred to this committee by the Surgeon General of the Public Health Service is to formulate definite specifications which may be used by the Public Health Service in the administrative action which it is required to take upon the supplies of drinking water offered by common carriers for the use of passengers carried in interstate traffic. The recommendations submitted apply, therefore, only to this special case, and are not proposed for more general application.

Since the purpose of the supervision which the Public Health Service exercises over these water supplies is to safeguard the health of the public, the examinations and specific requirements herein proposed have reference chiefly to forming a judgment of safety, and are designed especially to afford protection against the most serious danger which is associated with water supplies; namely, that of infection with typhoid fever and other diseases of similar origin and transmission. Less emphasis has been placed upon physical and chemical characteristics affecting the acceptability of water with respect to appearance, taste and odor, because these are matters of less fundamental importance and because, in actual experience, the water supplies which come under consideration, if satisfactory from the standpoint of safety, will usually be found satisfactory with respect to physical and chemical characteristics.

The first step toward the establishment of standards which will insure the safety of water supplies conforming to them is to agree upon some criterion of safety. This is necessary because "safety" in water supplies, as they are actually produced, is relative and quantitative, not absolute. Thus, to state that a water supply is "safe" does not necessarily signify that absolutely no risk is ever incurred in drinking it. What is usually meant, and all that can be asserted from any evidence at hand, is that the danger, if any, is so small that it cannot be discovered by available means of observation. Nevertheless, while it is impossible to demonstrate the absolute safety of a water supply, it is well established that the water supplies of many of our large cities are safe in the sense stated above, since the large populations using them continuously have, in recent years, suffered only a minimal incidence of typhoid fever and other potentially water-borne infections. Whether or not these water supplies have had any part whatsoever in the conveyance of such infections during the period referred to is a question that cannot be answered with full certainty; but the total incidence of the diseases has been so low that even though the water supplies be charged with responsibility for the maximum share which may reasonably be suggested, the risk of infection through them is still very small compared to the ordinary hazards of everyday life.[2]

The committee has, therefore, taken this better class of municipal water supplies as its standard of comparison with respect to safety, and proposes as a fair objective, that the water supplies furnished by common carriers to passengers

[1] Pub. Health Repts., **40**: 693 (Apr. 10, 1925).

[2] This evidence actually proves only that the water supplies in question have been generally "safe" in the past during the period of low prevalence of infection. The likelihood that they will continue to be equally or more safe in the future must, of course, be reckoned from other considerations, such as the probability of future change in the pollution of their watershed, the character and consistency of their protection, etc.

in interstate traffic be of comparable safety. As regards protection of the traveling public, such a standard is fair, since it implies that the use of the water supplied to them in travel shall not add to the almost negligible risk which is ordinarily incurred at home by those who habitually use water supplies of somewhat better than average quality. From the standpoint of the carriers also, this standard is believed to be fair and reasonable, since it refers to water supplies which are actually obtainable in all sections of the country and from a great variety of sources.

The next and principal task of the committee has been to set up objective requirements which will conform to this general standard of safety; that is, requirements which will ordinarily be fulfilled by the municipal supplies of epidemiologically demonstrated safety which constitute the standard of comparison, but will exclude supplies of less assured safety. Since there is no single and measurable characteristic of water supplies which bears any known and constant relation to actual safety, the standard recommended is composite, including certain requirements relative to the source and protection of the water supplies in question as indicated by a careful sanitary survey, and certain other requirements relative to bacterial content as shown by standard tests.

It is anticipated that little objection will be raised to the requirements laid down as to source and protection, at least to their general intent, because they are based upon well recognized principles of sanitary engineering, and because they are necessarily stated in general terms which imply a rather broad consideration of each supply from all angles and the exercise of discretion in forming an ultimate judgment of its fitness. The bacteriological standard, on the other hand, is stated in definite quantitative terms. This is unavoidable if such a standard be included at all, since the methods of bacteriological examinations are quantitative and yield results in the definite terms used in the standard. However, in view of the well-recognized principle that the significance of bacteriological examinations is variable, and must be interpreted with due regard to all other facts known about the particular water supply in question, the objection may be raised that a rigid application of this standard will arbitrarily exclude a considerable number of water supplies which conform to all other requirements and which competent opinion will consider to be quite safe. The validity of this criticism is recognized, but it is not considered of sufficient force to require or justify the lowering of the bacteriological standard proposed. This viewpoint appears proper when it is recognized that the definite terms of bacteriological quality in which this standard is expressed represent only agreement as to safety, and not as to limiting values beyond which demonstrable or even presumptive danger lies. Between the point on which the committee is in agreement as to the assured safety of water supplies and the point at which agreement could be reached as to their dangerous quality is a wide zone. Within the zone lie many water supplies which, if considered in the light of available evidence from all angles, are believed to be as safe as other supplies which conform to all the bacteriological requirements.

The committee, therefore, considers it preferable to recommend that in actual practice the bacteriological standard be applied, as are other requirements, with some latitude; in other words, that supplies which, on rigid inspection, are found to be satisfactory in other respects but fail to meet the bacteriological standard, may be accepted in the discretion of the certifying authority. In view of the character of the personnel entrusted with the responsibility for investigation and administrative action, the committee feels assured that this procedure is preferable to the alternative of rigid and automatic application.

Public Health Service Drinking Water Standards

Standards Adopted by the United States Public Health Service, Federal Security Agency, September 25, 1942, for Drinking and Culinary Water Supplied by Common Carriers in Interstate Commerce

(Superseding standard adopted June 20, 1925) [1]

In recommending the adoption of the revised Standards the Advisory Committee submitted a report discussing the requirements as follows:

REPORT OF THE ADVISORY COMMITTEE ON OFFICIAL WATER STANDARDS

The requirements for drinking (and culinary) water provided by common carriers for the use of passengers carried in interstate traffic, commonly known as the "Treasury Department Drinking Water Standards," were last revised in 1925, and published in the Public Health Reports of April 10 of that year. Since that time many improvements in water supply practice have been adopted with resulting increased uniformity of quality and safety to the consumer. Moreover, the Public Health Service, in recent years, has been requested by the American Public Health Association, the American Water Works Association, and the American Chemical Society to review the 1925 Standards. Accordingly, the Public Health Service has undertaken a revision of the Standards in order to have them conform more closely to current requirements for water supplies of attainable safety and potability.

To carry out such a revision the Surgeon General of the Public Health Service, on February 27, 1941, appointed the undersigned special Advisory Committee composed of representatives of various Federal organizations and scientific associations and including several members at large. A smaller subcommittee of Public Health Service officers was designated to prepare tentative suggestions for the consideration of the Advisory Committee.

After thorough consideration, the Advisory Committee recommends the adoption of the revisions as set forth in the text herewith submitted. The principal changes now proposed are:

(1) A distinct separation of the text into: (*a*) that portion containing the statement of the Standards and (*b*) that portion constituting a recommended manual of water works practice representing the judgment of the technical subcommittee composed of officers of the Public Health Service. This portion [to be published in the February JOURNAL] of the text is intended to serve as a guide to the reporting agency and should not be considered as indicating additional requirements to be met for certification of the water supply.

(2) In the bacteriological section, the use of 5–10-ml. portions or of 5–100-ml. portions is made optional; a minimum number of samples is to be examined monthly, the number depending upon the population served; the laboratories in which bacteriological examinations are made and the methods used in making them are subject to inspection at any time by the designated representative of the certifying authority.

[1] Pub. Health Repts., **40**: 693 (Apr. 10, 1925).

(3) Concentration limits for lead, fluoride, arsenic and selenium are included as part of the Standards and their presence in excess of the limits stated shall constitute ground for rejection of the supply. Limits in concentration that should not be exceeded, where other more suitable supplies are available, are given for copper, iron and manganese together, magnesium, zinc, chloride, sulfate, phenolic compounds, total solids and alkalinity.

(4) The results of recent studies on the potential pollutional hazards existing in the water supply systems of our communities due to faulty plumbing practices, cross-connections, inter-connections, etc., as well as the pollutional hazards which are due to faulty water plant and distribution system operational practices, any or all of which may jeopardize the safety of the water in the distribution system, have been adjudged as being of prime importance in the consideration of the requirements of these Standards. The utmost care and consideration have been given to the inclusion of those provisions which would serve to detect possible contamination arising in the distribution system and thus lead to its correction and further safeguarding of the traveling public.

The Committee believes that, in general, water supplies to be eligible for certification should meet all (sanitary, chemical and bacteriological) requirements of the Standards and that definite failure to meet any one of them should be ground for rejection or provisional certification, according to the judgment of the certifying authority. However, it is realized that the statement of an official standard of drinking water quality, to be generally applicable, must be interpreted reasonably. The Committee has attempted to take into consideration all aspects of the problem. It offers these Standards with the recommendation that the judgment and discretion of the certifying authority be exercised in their application.

MEMBERSHIP OF ADVISORY COMMITTEE ON REVISION OF THE DRINKING WATER STANDARDS [1]

Joseph W. Mountin, *Chairman, Assistant Surgeon General, States Relations Division, U.S. Public Health Service, Washington, D.C.*

J. K. Hoskins, *Secretary, Senior Sanitary Engineer, Chief, Sanitation Section, U.S. Public Health Service, Washington, D.C.*

Representatives of Federal Organizations

Food and Drug Administration: J. W. Sale, Senior Chemist, Food Division, Federal Security Agency, Washington, D.C.

U.S. Geological Survey: W. D. Collins, Chemist in Charge, Quality of Water Division, Department of the Interior, Washington, D.C.

Representatives of Scientific Associations

American Chemical Society: A. M. Buswell, Chief, Illinois State Water Survey Division, Urbana, Ill.

American Public Health Association: Abel Wolman, Professor of Sanitary Engineering, Johns Hopkins University, Baltimore, Md.

American Society of Civil Engineers: Arthur E. Gorman, Engineer of Water Purification, Bureau of Engineering, Department of Public Works, Chicago, Ill.

American Water Works Association: Charles R. Cox, Chief, Bureau of Water Supply, State Department of Health, Albany, N.Y.

Association of American Railroads: R. C. Bardwell, Superintendent, Water Supply, Chesapeake and Ohio Railroad, Richmond, Va.

[1] Official positions indicated are as of February 27, 1941, when the Committee was organized.

Conference of State Sanitary Engineers: Arthur D. Weston, Director and Chief Engineer, Division of Sanitary Engineering, State Department of Health, Boston, Mass.

Society of American Bacteriologists: A. C. Hunter, Principal Bacteriologist, Food and Drug Administration, Federal Security Agency, Washington, D.C.

Members at Large

Herman G. Baity, Professor of Sanitary Engineering, University of North Carolina, Chapel Hill, N.C.

R. E. Buchanan, Director, Agricultural Experiment Station, Iowa State College, Ames, Iowa

R. F. Goudey, Sanitary Engineer, Bureau of Water Works and Supply, Los Angeles, Calif.

Technical Subcommittee, Officers of the Public Health Service

J. K. Hoskins, Senior Sanitary Engineer, Chief, Sanitation Section, States Relations Division, Washington, D.C. (*Secretary*)

R. E. Tarbett, Senior Sanitary Engineer, Washington, D.C.

H. W. Streeter, Senior Sanitary Engineer, Stream Pollution Investigations, Cincinnati, Ohio

C. T. Butterfield, Principal Bacteriologist, Stream Pollution Investigations, Cincinnati, Ohio

C. C. Ruchhoft, Principal Chemist, Stream Pollution Investigations, Cincinnati, Ohio

Lawrence T. Fairhall, Principal Industrial Toxicologist, National Institute of Health, Bethesda, Md.

Part I—Public Health Service Standards

1. Definition of Terms

For the purpose of these Standards the terms designated herein below shall be defined as follows:

1.1. *Adequate protection by natural agencies* implies various relative degrees of protection against the effects of pollution in surface waters; dilution, storage, sedimentation, the effects of sunlight and aeration and the associated physical and biological processes which tend to produce natural purification; and, in the case of ground waters, storage in and percolation through the water-bearing material.

1.2. *Artificial treatment* includes the various processes commonly used in water treatment, both separately and in combination, such as storage, aeration, sedimentation, coagulation, rapid or slow sand filtration, chlorination and other accepted forms of disinfection. Rapid sand filtration treatment is commonly understood to include those auxiliary measures, notably coagulation and sedimentation, which are essential to its proper operation.

1.3. *Adequate protection by artificial treatment* implies that the method and degree of elaboration of treatment are appropriate to the source of supply; that the works are of adequate capacity to support maximum demands, are well located, designed and constructed, are carefully and skillfully operated and supervised by properly trained and qualified personnel, and are adequately protected against floods and other sources of pollution. The evidence that the protection thus afforded is adequate must be furnished by frequent bacteriological examinations and other appropriate analyses showing that the purified water is of good and reasonably uniform quality, a recognized principle being that irregularity in quality is an indication of potential danger. A minimum spec-

ification of good quality would be conformance to the bacteriological and chemical requirements of these Standards, as indicated in sections 3 and 4.

1.4. *Sanitary defect* means any faulty structural condition, whether of location, design or construction of water collection, treatment or distribution works, which may regularly or occasionally cause the water supply to be contaminated from an extraneous source, including dual supplies, bypasses, cross-connections or inter-connections (back-flow connections) or fail to be satisfactorily purified.

1.5. *Health hazard* means any faulty operating condition including any device or water treatment practice, which, when introduced into the water supply system, creates or may create a danger to the well-being of the consumer.

1.6. *Water supply system* includes the works and auxiliaries for collection, treatment and distribution of the water from the source of supply to the free-flowing outlet of the ultimate consumer.

1.7. *The coliform group of bacteria* is defined, for the purpose of these Standards, as including all organisms considered in the coli-aerogenes group as set forth in the *Standard Methods for the Examination of Water and Sewage*, eighth edition (1936), prepared, approved and published jointly by the American Public Health Association and the American Water Works Association, New York City. The procedures [1] for the demonstration of bacteria of this group shall be those specified herein, for:

(*a*) The completed test, or

(*b*) The confirmed test when the liquid confirmatory medium brilliant green bile lactose broth, 2 per cent, is used, providing the formation of gas in any amount in this medium during 48 hours of incubation at 37°C. is considered to constitute a positive confirmed test, or

(*c*) The confirmed test when one of the following liquid confirmatory media is used: crystal violet lactose broth, fuchsin lactose broth or formate ricinoleate broth. For the purpose of this test, all are equivalent, but it is recommended that the laboratory worker base his selection of any one of these confirmatory media upon correlation of the confirmed results thus obtained with a series of completed tests, and that he select for use the liquid confirmatory medium yielding results most nearly agreeing with the results of the completed test. The incubation period for the selected liquid confirmatory medium shall be 48 hours at 37°C. and the formation of gas in any amount during this time shall be considered to constitute a positive confirmed test.

1.8. *The standard portion of water* for the application of the bacteriological test may be either:

(*a*) Ten milliliters (10 ml.) or

(*b*) One hundred milliliters (100 ml.).

1.9. *The standard sample* for the bacteriological test shall consist of five (5) standard portions of either:

(*a*) Ten milliliters (10 ml.) or

(*b*) One hundred milliliters (100 ml.) each.

In any disinfected supply the sample must be freed of any disinfecting agent

[1] This reference shall apply to all details of technique in the bacteriological examination, including the selection and preparation of apparatus and media, the collection and handling of samples, and the intervals and conditions of storage allowable between collection and examination of the water sample.

within twenty (20) minutes of the time of its collection.[2]

1.10. *The certifying authority* is the Surgeon General of the United States Public Health Service or his duly authorized and designated representatives and the *reporting agency* shall be understood to mean the respective state departments of health or their designated representatives.

2. As to Source and Protection

2.1. The water supply shall be:

(*a*) Obtained from a source free from pollution; or

(*b*) Obtained from a source adequately purified by natural agencies; or

(*c*) Adequately protected by artificial treatment.

2.2. The water supply system in all its parts shall be free from sanitary defects and health hazards and shall be maintained at all times in a proper sanitary condition.

3. As to Bacteriological Quality

3.1. *Sampling*—The bacteriological examination of water considered under this section shall be of samples collected at representative points throughout the distribution system.

The frequency of sampling and the location of sampling points on the distribution system should be such as to determine properly the bacteriological quality of the water supply. The frequency of sampling and the distribution of sampling points shall be regulated by the certifying authority after investigation of the source, method of treatment, and protection of the water concerned.

The minimum number of samples to be collected from the distribution system and examined by the reporting agency or its designated representative each month should be in accordance with the number as determined from the graph presented in Fig. 1 of these Standards[3] which is based upon the relationship of population served and minimum number of samples per month:

Population served	*Min. no. of samples per mo.*
2,500 and under	1
10,000	7
25,000	25
100 000	100
1,000,000	300
2,000,000	390
5,000,000	500

The laboratories in which these examinations are made and the methods used in making them shall be subject to inspection at any time by the designated representative of the certifying authority. Compliance with the specified procedures, or failure to comply therewith, and the results obtained shall be used as a basis for certification, or refusal of certification, by the certifying authority in accordance with the application given below.

3.2. *Application*—Applications 3.21 and 3.22 given below shall govern when ten-milliliter (10-ml.) portions

[2] In free samples of chlorine or chloramines, the procedure given on page 286 in *Standard Methods* (eighth edition, 1936), paragraph A—1, option 1, or paragraph A—2, shall be followed.

[3] For the purpose of uniformity and simplicity in application, the number of samples to be examined each month for any given population served shall be determined from the graph in accordance with the following:

For populations of 25,000 and under to the nearest 1

For populations of 25,001 to 100,000 to the nearest 5

For populations of 100,001 to 2,000,000 to the nearest 10

For populations of over 2,000,000 to the nearest 25.

are used and applications 3.23 and 3.24 shall govern when one hundred-milliliter (100-ml.) portions are used.[4]

3.21. Of all the standard ten-milliliter (10-ml.) portions examined per month in accordance with the specified procedure, not more than ten (10) per cent shall show the presence of organisms of the coliform group.

3.22. Occasionally three (3) or more of the five (5) equal ten-milliliter (10-ml.) portions constituting a single standard sample may show the presence of organisms of the coliform group, provided that this shall not be allowable if it occurs in consecutive samples or in more than:

(*a*) Five (5) per cent of the standard samples when twenty (20) or more samples have been examined per month.

(*b*) One (1) standard sample when less than twenty (20) samples have been examined per month.

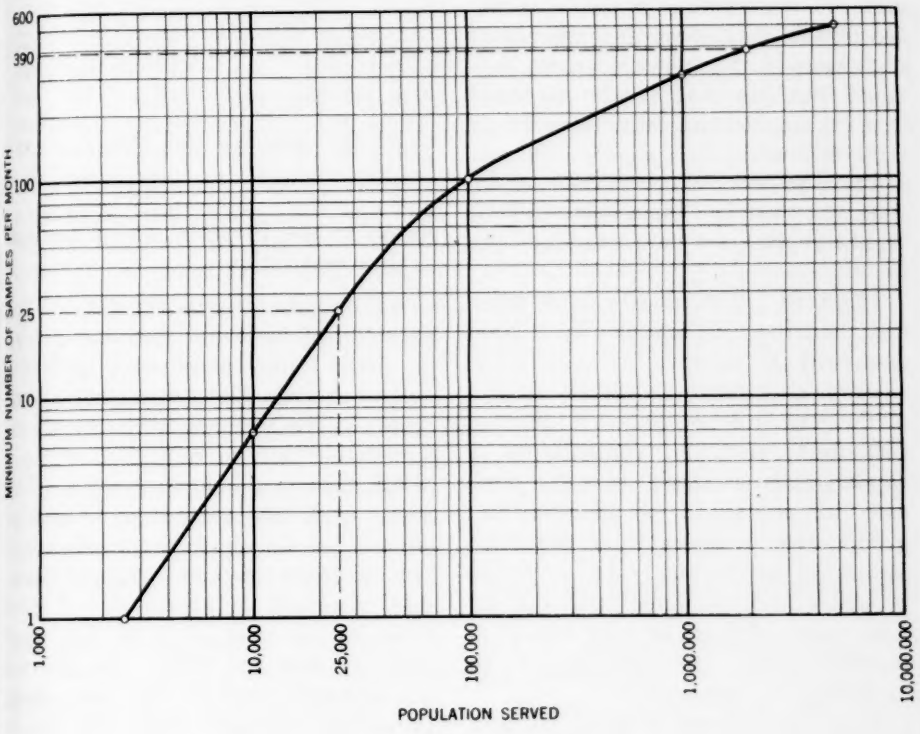

FIG. 1

Provided further that when three or more of the five equal ten-milliliter (10-ml.) portions constituting a single standard sample show the presence of organisms of the coliform group, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from

[4] It is to be understood that in the examination of any water supply the series of samples for any one month must conform to both of the above requirements, either 3.21 and 3.22 or 3.23 and 3.24, respectively.

at least two consecutive samples show the water to be of satisfactory quality.[5]

3.23. Of all the standard one hundred-milliliter (100-ml.) portions examined per month in accordance with the specified procedure, not more than sixty (60) per cent shall show the presence of organisms of the coliform group.

3.24. Occasionally all of the five (5) equal one hundred-milliliter (100-ml.) portions constituting a single standard sample may show the presence of organisms of the coliform group, provided that this shall not be allowable if it occurs in consecutive samples or in more than:

(*a*) Twenty (20) per cent of the standard samples when five (5) or more samples have been examined per month.

(*b*) One (1) standard sample when less than five (5) samples have been examined per month.

Provided further that when all five of the standard one hundred-milliliter (100-ml.) portions constituting a single standard sample show the presence of organisms of the coliform group, daily samples from the same sampling point shall be collected promptly and examined until the results obtained from at least two consecutive samples show the water to be of satisfactory quality.[6]

3.25. The procedure given, using a standard sample composed of five standard portions, provides for an estimation of the most probable number of coliform bacteria present in the sample as set forth in the following tabulation:

No. of portions		M.P.N. of coliform bacteria per 100 ml.	
Negative	Positive	When 5–10 ml. portions are examined	When 5–100 ml. portions are examined
5	0	Less than 2.2	Less than 0.22
4	1	2.2	.22
3	2	5.1	.51
2	3	9.2	.92
1	4	16.0	1.60
0	5	More than 16.0	More than 1.60

4. As to the Physical and Chemical Characteristics

4.1. *Physical characteristics*—The turbidity of the water shall not exceed 10 ppm. (silica scale), nor shall the color exceed 20 (standard cobalt scale). The water shall have no objectionable taste or odor.

4.2. *Chemical characteristics*—The water shall not contain an excessive amount of soluble mineral substance, nor excessive amounts of any chemicals employed in treatment. Under ordinary circumstances, the analytical evidence that the water satisfies the physical and chemical standards given in sections 4.1 and 4.21 and simple evidence that it is acceptable for taste and odor will be sufficient for certification with respect to physical and chemical characteristics.

4.21. The presence of lead (Pb) in excess of 0.1 ppm., of fluoride in excess of 1.0 ppm., of arsenic in excess of 0.05 ppm., of selenium in excess of 0.05 ppm., shall constitute grounds for rejection of the supply.

[5] When this occurs, and when waters of unknown quality are being examined, simultaneous tests should be made on multiple portions of a geometric series ranging from 10 ml. to 0.1 ml. or less.

[6] When this occurs, and when waters of unknown quality are being examined, simultaneous tests should be made on multiple portions of a geometric series ranging from 100 ml. to 1.0 ml. or less.

These limits are given in parts per million by weight and a reference to the method of analysis recommended for each determination is given in section 4.31. Salts of barium, hexavalent chromium, heavy metal glucosides or other substances with deleterious physiological effects shall not be allowed in the water supply system.

Ordinarily analysis for these substances need be made only semi-annually. If, however, there is some presumption of unfitness because of these elements periodic determination for the element in question should be made more frequently.

4.22. The following chemical substances which may be present in natural or treated waters should preferably not occur in excess of the following concentrations where other more suitable supplies are available in the judgment of the certifying authority. Recommended methods of analysis are given in section 4.3.

Copper (Cu) should not exceed 3.0 ppm.

Iron (Fe) and manganese (Mn) together should not exceed 0.3 ppm.

Magnesium (Mg) should not exceed 125 ppm.

Zinc (Zn) should not exceed 15 ppm.

Chloride (Cl) should not exceed 250 ppm.

Sulfate (SO_4) should not exceed 250 ppm.

Phenolic compounds should not exceed 0.001 ppm. in terms of phenol.

Total solids should not exceed 500 ppm. for a water of good chemical quality. However, if such water is not available, a total solids content of 1,000 ppm. may be permitted.

For waters softened by the lime soda process the total alkalinity produced should not exceed the hardness by more than 35 ppm. (calculated as $CaCO_3$).

For chemically treated waters the phenolphthalein alkalinity (calculated as $CaCO_3$) should not be greater than 15 ppm. plus 0.4 times the total alkalinity. This requirement limits the permissible pH to about 10.6 at 25°C.

For chemically treated waters the normal carbonate alkalinity should not exceed 120 ppm. Since the normal alkalinity is a function of the hydrogen ion concentration and the total alkalinity, this requirement may be met by keeping the total alkalinity within the limits suggested when the pH of the water is within the range given. These values apply to water at 25°C.

pH range	*Limit for total alkalinity (ppm. as $CaCO_3$)*
8.0 to 9.6	400
9.7	340
9.8	300
9.9	260
10.0	230
10.1	210
10.2	190
10.3	180
10.4	170
10.5 to 10.6	160

4.3. *Recommended methods of analysis:*

4.31. Ions with required limits of concentration.

Arsenic (As): Official and Tentative Methods of Analysis. Association of Official Agricultural Chemists, 1940, p. 390; also "Colorimetric Microdetermination of Arsenic," Morris B. Jacobs and Jack Nagler. Industrial and Engineering Chemistry—Anal. Ed., **14**: 442 (1942).

Fluoride (F): *Standard Methods for the Examination of Water and Sewage.* American Public Health Association and American Water Works

Association, 1936, p. 36; also Methods of Determining Fluorides, Committee Report, A. P. Black, Chairman. JOURNAL American Water Works Association, **33**: 1965–2017 (1941).

Lead (Pb): *Standard Methods for the Examination of Water and Sewage*. American Public Health Association and American Water Works Association, 1936, p. 26.

Selenium (Se): Official and Tentative Methods of Analysis. Association of Official Agricultural Chemists, 1940, pp. 11 and 417; also Robinson, W. O., Dudley, H. C., Williams, K. T. and Byers, Horace G. The Determination of Selenium and Arsenic by Distillation. Industrial and Engineering Chemistry—Anal. Ed., **6**: 274 (1934).

4.32. Ions and substances with suggested limits of concentration.

Copper (Cu): *Standard Methods for the Examination of Water and Sewage*. American Public Health Association and American Water Works Association, 1936, p. 25.

Iron (Fe) and manganese (Mn): *Ibid*. p. 74 and p. 82.[7]

Magnesium (Mg): *Ibid*, p. 79.[7]

Zinc (Zn): *Ibid*, p. 28.[7]

Chloride (Cl): *Ibid*, p. 34.[7]

Sulfate (SO_4): *Ibid*, p. 85.[7]

Phenolic compounds: Ibid, p. 245.[7] With dibromquinonechlorimide as an indicator.

Total solids: Ibid, p. 56.[7]

Alkalinity: Ibid, pp. 59 and 64.[7]

[7] For the chemical determinations referred to in this report, when given, the methods of analysis recommended by the Association of Official Agriculture Chemists are satisfactory and may be substituted for those recommended by the American Public Health Association, which are specifically cited.

Abstracts of Water Works Literature

Key: In the reference to the publication in which the abstracted article appears, **34:** 412 (Mar. '42) indicates volume 34, page 412, issue dated March 1942. If the publication is paged by the issue, **34:** 3: 56 (Mar. '42) indicates volume 34, number 3, page 56, issue dated March 1942. Initials following an abstract indicate reproduction, by permission, from periodicals, as follows: *B.H.—Bulletin of Hygiene (British); C.A.—Chemical Abstracts; P.H.E.A.—Public Health Engineering Abstracts; W.P.R.—Water Pollution Research (British); I.M.—Institute of Metals (British).*

WARTIME WATER WORKS PROBLEMS

Protection and Maintenance of Public Water Supplies Under War Conditions. San. Eng. Bul. 1., Med. Div., U.S. Office of Civilian Defense (Sept. '42). No metropolitan area can long sustain community life resistance against military force without adequate supply of water. Fall of Hong Kong and Singapore cited. Vulnerability of water distr. systems to aerial bombing clearly demonstrated often. Service maint. and restoration during and after intense bombardment major problems demanding max. effort. Service interruptions by enemy action serious hazards to pub. safety and of vital concern to military effort. Bul. outlines co-op. plan of mutual aid for water works, describing functions of participating officials and suggesting activities and specific measures to be considered by local water works for maintg. service during emergency and rendering prompt aid to neighboring communities in need. Plans and suggestions gen. No detailed plan can be devised because laws and functions of state agencies and local communities not uniform; also many variations in water supply installations. Major considerations covered: legal considerations in mutual aid program; state organization plan, state and zone water co-ordinators; organization and development of mutual aid plan within zone as to auxiliary sources of supply, inventory of materials, equip. and personnel, air raid protection; inter-system connections; auxiliary sources of supply; inventories of resources in zone as to material and equip., personnel and training program; local water works; emergency repair depots (light, intermediate, major); local water works in relation to local civilian defense organization; control center and relation to water works; communications; aircraft warning service; air raid warning signals; 10 home water supply precautions; prepn. of oil tanks for distributing drinking water; sterilization of water mains, with table of equivalents.—*Ralph E. Noble.*

Water Supplies and Sanitation Under War Conditions. WARREN J. SCOTT. Conn. Health Bul. **56:** 223 (Oct. '42). Steps taken by water co-ordinators and state depts: (1) development of inventories of water works supplies and equip. for mutual aid in case of need; (2) police and protection surveys by Pub. Utilities Com., state police and health depts.; (3) visits to each water utility by dist. co-ordinators and state san. engrs. to review emergency operating procedures; (4) prepn. and distr. of emergency notices and directions for water consumers in case of air raids or damage to supplies; (5) surveys of possible inter-system connections; (6) surveys of chlorine supplies for disinfection; (7) field tests of water storage in gasoline and oil trucks for emergency distr.; (8) conferences with sewer officials re sewer repairs; (9) prepn. and distr. of notices to water officials re water main disinfection; (10) conferences with fire chiefs and health officers re emergency water supply plans; (11) prepn. of program for training auxiliary water works repair squads in co-op. with staff of state defense council; (12) prepn. and distr. to health officers of notices re sanitation in defense. Tremendous indus. activity in Conn. made enormous demand on pub. supplies. Latter supplying far in excess of peacetime expectations for years ahead. In some communities, supply adequacy insuffi-

cient to combat combined greatly enlarged consumption and drought. Yr. or so ago, foresighted Conn. water officials assembled substantial supplies of pipe, valves and fittings for emergency repairs. War demands, however, seriously depleted inventories. Materials situation so critical, WPB trying to reduce inventories to lowest feasible point with mutual aid program, whereby pipe, valves and materials to some extent shared between utilities for necessary constr. Substantial no. of indus. plants dependent upon private well supplies. State health dept. re-checking all private factory supplies in co-op. with local health officers to safeguard health of indus. workers. Cross-connections guarded against. *Sewage Disposal:* Great upswing in indus. activity plus large influx of war workers with accompanying housing developments created serious problems of sewage and indus. waste disposal. Tributary flows reaching munic. sewage treatment plants increased to point where no. seriously overloaded, with resulting effect on streams receiving discharge. Increased vol. and changing character of indus. wastes introduced new problems at munic. sewage treatment plants. Oil discharges constant source of trouble, but elimn. being undertaken. Indus. waste discharged into state waters created serious poln. problem. Remedy not easy because of shortage of materials essential for extensive proper treatment by indus. plants. Erection of some housing developments on limited areas with poor soil conditions for underground absorption of sewage effluents created san. problems. Abatement almost impractical for duration because of materials shortage.—*Ralph E. Noble.*

Supervision of Public Water Supplies in Wartime. E. A. REINKE. Weekly Bul., Calif. State Dept. of Pub. Health. **21:** 159 (Oct. 24, '42). In time of war emergency, particularly important that adequate facilities provided for pub. water supply, fire protection and wartime indus. Experience in catastrophes in Calif., other sections of U.S. and under European war conditions demonstrated need for emergency or auxiliary domestic water supplies from private wells or other potable sources pumped to system or distributed in tank trucks, milk cans or bottles, as already done in many instances throughout country. Each community should have detailed plans for such supplies. Assurance of safe emergency supply, with provision for disinfection as needed, proper function of local health dept. Emergency fire protection obtained through separate system of water piping, by pumping emergency supply to domestic water system, or by pumping through fire hose direct to fire from tanks, cisterns, swimming pools or creeks. Any program using emergency supply pumped to domestic water system should be carefully studied in advance to assure adequate protection of pub. health. Cross-connections possibly permitting contamn. of domestic water supply by pold. supply present one of major problems for both pub. health and water works officials. Because of importance of fire protection, many indus. developed or planning emergency supplies from dangerous or doubtful sources. In some instances cross-connected with pub. domestic supply. State Bd. of Health officially cognizant of condition June 27, '42, in resolution regarding same distributed to health and water works agencies. Seeing need, health officials requested addnl. personnel to supervise water supplies. Emergency state funds made men available for field work. These regional water works advisers visited larger communities and those of greatest growth during emergency. In each area, problems reviewed with health officers, water, fire and civilian defense officials. Check list of mutual aid prepd., including: maps of system, valve records, inter-connections and cross-connections survey, auxiliary supplies and chlorination equip., chlorine supplies and mutual aid inventory, auxiliary power supplies, protection and lab. control. In addn., organization of local water dept. for defense, with particular attention to representation on civilian defense com. and at control center; expanding repair work; investigation, fingerprinting and identification of personnel. Encouraged frequent san. surveys in addn. to more frequent and extensive sampling of pub. water supplies. Co-ordinated effort by all necessary to protect water supplies adequately. Requires careful study of each local problem by health depts., water works officials, fire depts., civilian defense officials and, in some instances, representatives of indus.—*Ralph E. Noble.*

Defense Program of Water Service Company in 29 Communities. J. H. JAMISON. Western City **18:** 7: 22 (July '42). 29 cities, towns, rural dists. supplied with domestic and indus. water by Calif. Water Service Co. Maint. of adequate supply, particularly during and after incidents, vitally important to community safety and welfare. Standardized

procedure followed in setting up system of civilian defense in co-op. with city and county councils of civilian defense. Room in warehouse, office or room in another company-owned bldg. blacked out, equipped with unlisted telephone, auxiliary lights, plat maps and termed "headquarters" (hq.) to distinguish it from city control center. In cities where main arterials might be difficult to cross in incident, established sub-hq. equipped same as main hq. In large cities, at least 3 employees on call to receive blue signal from control center. Communications to other employees then fan out and every one notified of alert in 5 min. Blacked out trucks dispersed in each community, usually at home of employees on call. If walking distance too great or private transportation unavailable, trucks proceed to hq. or sub-hq. along predetd. route picking up employees at designated points. Each truck equipped with gate valve keys, picks, shovels and other emergency equip. Each employee has gas mask, appropriate arm-band and identification card with photo and signature. Trucks equipped with luminous "W" on windshield for easy identification by employees en route to hq.; or by messenger trying to locate same after incident. As city and county control centers primarily for reception and dispatch of messages or incidents, company felt wiser to establish mgrs. and supts. in own hq. Mgr. or supt. best qualified to dispatch crews. Every male employee subject to call on blue signal. Few female employees act as telephone operators at company hq. Records kept of time employee notified and reported and details of incidents. Work in complete harmony with city and county defense councils. Very little repair work during raid because light required to repair fractured main. Efforts confined largely, therefore, to opening and closing gate valves.—*Ralph E. Noble.*

Water and Power. ANON. Western City **18**: 9: 42 (Sept. '42). Water and power vitally essential to every-day, peacetime operations of modern cities, loaded with even greater responsibilities and duties under war conditions. In Los Angeles, exacting demands of aircraft, shipbuilding and other indus. fully met without impairing normal service to 1,600,000 pop., demonstrating importance of long-range planning by munic. dept. of water and power. Largest constr. project under way is harbor steam generating 65,000,000-kw. plant to supply addnl. power equiv. to need of 200,000 pop. Inter-system connection or "pooling" program formulated in co-operation with WPB for strengthening elec. service in city and all southern Calif. area. 238-mi. aqueduct, traveling remote and rugged wastes, placed under intensive armed guard patrol of 300. Also, more than 100 Calif. State Guardsmen assigned to similar duty, camps being supplied by water and power dept. Supplementing these, emergency volunteer guard force of 300 organized from regular dept. employees, to be called out only in great emergency. They hold revolver practice and test mobilizations. Camp outfits and staple foodstuffs ready for instant transport. Protection of city water supply to avoid poln. a 24 hr. a day job in peace or war. Now, even greater attention given thereto. New tests added to lab. routine to detect injurious chems. not normally hazardous.—*Ralph E. Noble.*

San Francisco Votes Bonds for Wartime Fire and Water Department Needs. ANON. Western City **18**: 7: 26 (July '42). Voters approved bonds primarily for war protection purposes: $3,000,000 for fire dept.; $1,250,000 for supplementary water supply in case of disaster. Proposed equip. listed. Proposed water works improvements provide for steam pumping plant and mains to use Lake Merced, within city gates, affording enough water for approx. 40-day normal need. Uncertain whether priorities will be granted for materials and equip.—*Ralph E. Noble.*

Local Emergency Water Supply Program Recommended to Local Defense Councils by the Illinois Council of Defense. State of Illinois (Sept. '42). Without exception, water supply most important utility in community. No effort should be spared to maint. service. Interruption serious hazard to health and pub. safety. In many munics. vital concern to war effort and one of most important phases of local civilian protection program. Local water supply program consists of protection, maint. and operation of supply source; maintg. service in distr. sys.; and supplying water for fire fighting, drinking and domestic use in case pub. supply fails. Following program designed to assist local communities in maintg. service under all conditions: *I. State Mutual Aid Plan:* Provides for assistance between communities; also aid by and within community itself. State divided into 10 zones with water works co-ordinator in each. All

munics. sent inventory blanks for listing all equip. available for emergency use. This information now in hands of co-ordinators and on file with state health dept. All cities sent information re protecting pub. water supply and requested to appoint water works supt. to head local emergency water corps. *II. Local Emergency Water Corps:* Activities consist of handling emergencies related to pub. water supply itself and, if latter fails, carrying out plan for supplying water for fire fighting, drinking and gen. domestic use. Each community should have local water organization integrated into local civilian protection program. Latter described according to organization, training personnel, duties. *III. Communications:* Facilities should be available to notify pub. if necessary to boil all drinking water, or if pub. supply placed out of service or other pertinent information. *IV. Co-operation With Local Depts.* Recommendations relating to fire dept., other pub. works and utilities detailed. 10 water supply precautions with reasons, appended. These elaborated in following abstract.—*Ralph E. Noble.*

Emergency Sanitation Procedures. RALPH E. TARBETT. Am. J. Nursing **42:** 865 (Aug. '42). Maint. of reasonable san. stds. in areas affected by enemy action, a major concern of OCD. Med. Div. includes San. Eng. Sec. staffed with U.S.P.H.S. officers. Through established state and local health authorities, section plans and assists adoption of adequate measures to safeguard san. facilities against war hazards. *Water Supplies:* Of paramount importance to maint. adequate safe water supply under any circumstance. All states adopting precautionary measures to this end. Certain rules re water in air attack recommended: Keep at least 1 qt. of water per person available in house. When service fails, immediately discontinue using flush toilets and turn off all faucets and heating units to hot-water equip. Do not fill bathtubs following or during air raid alarms. Might reduce pressure in mains and shorten supply for fighting fire. Leave principal valves for trained men to attend. Remember water dept. knows service off in area. *Telephoning unnecessary.* Protect health by boiling water for drinking and cooking 5 min. during first 24 hr. of restored service unless health dept. advises otherwise. Accept chlorine tastes in drinking water. Indicate safety. Do not drink water from other sources than taps or carts operated by authorities, unless properly disinfected. If boiling not feasible, emergency supplies rendered satisfactory by several means. For disinfection use either high test chlorine prepns. (H.T.H., Perchloron, etc.) or lesser value chlorine disinfectants. Use appropriate amts. of each to give 3 ppm. available Cl_2. Weaker household chlorine prepns. used directly, 3 drops/gal. Chlorinated lime, H.T.H. and Perchloron, 6 to 20 times as high in available Cl_2, should first be diluted by prepg. chlorine soln. therefrom. Add 6 level teaspoons of chlorinated lime or 2½ of H.T.H. or Perchloron, to 1 pt. of water. Let stand 5 min., pour off clear liq. and use 3 drops/gal. when needed. Water turbidity consumes chlorine. Removed by passing through cotton cheesecloth filter. Night before, treat quant. of water required next day. Water chlorinated same day should not be used until 30 min. after treatment. Milk use and treatment and excreta and garbage disposal discussed.—*Ralph E. Noble.*

Air-Raid Organization Measures for Water Supply Protection. ANON. Eng. News-Rec. **128:** 990 (June 18, '42) (*see also* Jour. A.W.W.A. **34:** 1343 ('42)). Each div. and bureau of Chicago Dept. of Public Works has developed civil defense plan and organization for protection and repair of various facilities, procedures being outlined in manuals. Technical direction of operations necessary for safeguarding water supply responsibility of Div. of Water Purif. Outline of safety measures given.—*R. E. Thompson.*

Water and the War. *Philadelphia's Metropolitan District Carries on Successful Campaign to Eliminate Wasting Water Vital to War Effort.* ELLWOOD J. TURNER. State Govt. **15:** 177 (Sept. '42) (*see also* Am. City **57:** 11: 44 (Nov. '42)). Specific conditions compelling water conservation program included: (1) tremendous expansion of war indus. requiring ever-increasing supply of relatively pure water for mfg. processes; (2) accelerated spread of defense and war housing developments bringing thousands of new users to existing water systems; (3) abnormal increase in home consumption from increased employment and pop. increases unabsorbed by new housing developments. 3 water agencies supply more than 92% of 2½ million pop. in metropolitan dist., obtaining water from Schuylkill and Del. Rivers and tributaries of adequate flow for purpose. Max. capac. of 3 major water filtration and distr. systems approx. 460 mgd. against normal peacetime max. demand of 440

mgd. Without conservation measures, estd. demand would be 500 mgd., impossible to meet with present facilities. Periodic and routine checks on operation and domestic and indus. usage indicated 50 mgd. careless waste and needless use All ¾ million homes in Phila. Dist. circularized by close co-op. of civilian defense agencies. Posters, windowcards, leaflets, radio, press, schools, organizations, broadcast gospel of water conservation. Pub. agencies took initiative to exam. and repair all water outlets. Govt. employees urged to practice conservation measures at work and home. Water pressure control by valve manipulation at night and periodic checking of station pressures eased burden somewhat. Hydrant and valve inspections and repairs increased; underground leak and waste surveys intensified. Campaign cost about $5,000. Certain expenses absorbed by different organizations. *Results:* Indicated great majority of citizens in 5-county Phila. Metropolitan Dist. responded patriotically. Estd. use in June '42, 30 mgd. less than in June '41. Not true est., however, because does not reflect tremendously increased demands in 12-mo. period by war indus., housing and employment. Normally these would result in 375 mgd. demand. Leak stoppage, ending wasteful use as by excessive sprinkling, street showers, etc., produced estd. 25 mgd. decrease from last yr. Adoption and practice of water conservation measures to extent of 65 mgd. indicated. Practice of thrifty water use by each citizen must go on if increasingly severe strain on Dist. water supply systems to be avoided, with all risks attendant upon breakdowns in mech. equip. and resultant inadequacies in water supply for wartime purposes and protection of pub. health.—*Ralph E. Noble.*

Research and Control. NORMAN J. HOWARD. Can. Engr.—Wtr. & Sew. **80:** 9: 24 (Sept. '42). Criticism of adoption by Dominion Dept. of Pensions & National Health of presumptive test for coliform organisms as criterion of water qual. in recent Order-in-Council relating to water supplies in Canada (*see* Jour. A.W.W.A. **34:** 1739 ('42); Can. Engr. —Wtr. & Sew. **80:** 9: 15 (Sept. '42); Eng. Cont. Rec. **55:** 37: 15 (Sept. 16, '42); W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** D: 1: 1 (Oct. '42)). Occurrence of spurious presumptive pos. tests for coliform bacteria, particularly in examn. of chlorinated water, chief problem confronting water analysts for many yr. Never demonstrated that water which gives these non-confirming presumptive pos. tests capable of causing intestinal disturbances; therefore, condemnation of water supplies on basis of pos. presumptive tests alone unwarranted. Probably a no. of adequately controlled water supplies in America which could not consistently meet such a std. Absence of infection from such supplies over period of years would seem conclusive evidence that non-confirming presumptive pos. tests not very important. In addn., condemnation of water supplies without making complete san. survey to det. most probable source of poln. fundamentally wrong. Stds. of purity must necessarily be severe, but can be too stringent.—*R. E. Thompson.*

Emergency Water Planning. ANON. Munic. Jour. & Local Govt. Admin. (Br.) **50:** 1249 (Oct. 9, '42). London Metropolitan Water Bd. has provisional plans for emergency water distr: by mobile tanker from Bd's. own resources; from private wells or direct to callers; and from misc. sources. Authorized £10,000 for repairing hydrants to private supplies. In addn., £34,000 required for materials, tools and labor; £1,134 for chems. containers and sterilization. Ministry of Health intimated capital expenditures reimbursable for approved water plant projects at private or commercial sources.—*Ralph E. Noble.*

Some Aspects of Water Purification in Relation to the Army. J. L. FREED AND A. GOLDBERG. S. Afr. Digest War Med. **1:** 3: 43 (Sept. '41) (*see also* Wtr. & Wtr. Eng. (Br.) **45:** 154 (Oct. '42)). Must be realized that enemy might deliberately pollute isolated water supplies by addn. of either org. substances or inorg. materials. Therefore, water must first be tested chemically by means of specific app. supplied, to det. presence or absence of arsenic, antimony, cyanide, heavy metals and also for possibility of gaseous poln. by Lewisite and mustard gas. Should mineral poln. be present, and no other source of supply available, demineralization must be carried out—provided equip. for such treatment is at hand. Possibility of a well being contamd. by presence of dead animal must always be borne in mind. In case of well supplies, well should be thoroughly cleaned out before normal water treatment applied. May be done with excess lime, or with chlorinated lime added to give 1% soln. in well water. Afterwards, well

should be pumped out and allowed to refill. Any necessary repairs on well structure should be proceeded with, adequate cover fitted, and ground cleared of refuse from around well. Horrocks' test should be carried out twice daily until fairly const. figure obtained. Finally, sufficient potassium permanganate should be added to render water faintly "pink." Water can then be drawn from well, and that required for drinking purposes can be sterilized with quant. of bleach indicated by Horrocks' test. In supplies from streams and rivers, mineral poln. unlikely but always possibility of poln. upstream, usual cause being ablution, waste water and watering of animals. In occupation of town, local water supply must come under jurisdiction of military authorities. If local treatment plant destroyed, alternative plant should be provided and should consist of mobile units capable of pumping, filtering and sterilizing water with subsidiary tankers and trailers for storage and distr. Water pumped by means of centrifugal pump which also feeds chems. for purpose of flocculation, into pipeline. Water then passed into flocculation chamber, from which it passes into system of h-p. filters; clarified water then passing over weir measuring tank where requisite quant. of sterilizing solns. added. Chloramine process employed where no considerable deg. of org. poln. In event of latter condition, process of superchlorination followed by de-chlorination must be resorted to. In absence of organized surface supplies, for example, with small isolated body of troops, improvised methods of water clarification necessary with only equip. available—empty oil and petrol drums, semi-rotary pump and hose pipe. Several methods outlined, two of which described and illustrated.—*B.H.*

Rapid and Certain Disinfection of Drinking Water in the Field Under Normal Conditions. M. KOITSHEV. Sanit. Tech. (Bulg.) No. 8: 87 ('40). Deals with various methods for disinfecting water supplies for troops in field. Boiling efficient, but lengthy process and makes the water unpalatable. Treatment with potassium permanganate will yield water free from pathogenic bacteria in 3–4 hr.; chlorination will do same in about 30 min. Treatment with ozone or with ultra-violet rays impracticable under field conditions. Treatment with metals slow and only suitable for clear water. Filtration through Seitz or Berkefeld filters produces clear water entirely free from bacteria. These filters small and light and simple to construct and operate. In Seitz filter, asbestos plates form filtering medium; these plates cannot be cleaned and, after they have been used, bacteria grow through them within 2 or 3 days, so that they have to be changed. In Berkefeld filter filtering medium consists of *kieselguhr* filter candles. Water passes from outside to inside of candle. When the pores stopped up, outside cleaned with soft brush, and candle washed in pure water and chlorinated. Berkefeld filter cheaper to use than Seitz and both produce about same results. Berkefeld filter contg. 5 candles will treat 250 l. of water per hr.; equip. with pump and 5 spare candles in container weighs about 30 kg. Larger units available for stationary or mechanized troops. —*W.P.R.*

Properties of Luminescent Materials. C. E. BARNETT. Chem. & Eng. News **20**: 1006 (Aug. 25 '42). In wartime, many military and some civilian operations must be performed under greatly decreased illumination. Properties of luminescent materials therefore of interest, especially since some misconceptions can lead to disappointments in use of fluorescent and phosphorescent substances. [In Oct.'42, OCD Director Landis advised against the use of phosporescent devices in a statement to defense councils, basing his recommendation on 3 considerations: (1) brightness of such materials, even after few minutes' exposure to light, not much greater than that of white paint under starlight; (2) many such materials deteriorate so rapidly in sun and rain that they are not suitable for extended outdoor use; and (3) large proportion of such materials use highly critical chems. that would be diverted from war production.]

For few min. after extinguishing exciting radiation up to 2 hr. in darkness, brightness in most phosphorescent materials ranges between 10 and 0.1 microlamberts. If color diff. involved, brightness measurements in this region difficult, because luminosity curve of eye becomes progressively more blue-sensitive and less red-sensitive below 1′ lambert (Purkinje effect). Most pronounced between 200 and 1 microlambert. Below 0.5 microlambert, luminosity curve again const., corresponding to dark-adapted eye. British Std. Specifications, BS/ARP 18, point out that, because of Purkinje phenomenon, relative values of brightness of diff. colored surfaces of low brightness expressed in ft. lamberts have little

bearing on relative effective brightness as directly judged by eye. Wide-angle photometer for measuring low brightness described and resulting decay curves given for zinc sulfide, zinc-cadmium sulfides, calcium sulfide and strontium sulfide phosphors. Copper used as activating metal for first two phosphors. Zinc-cadmium prepn. contained approx. 80% ZnS and 20% CdS. Bismuth used to activate Ca and Sr phosphors. CaS phosphor contained 80% CaS and 20% SrS, while SrS had approx. reverse compn. Test panels painted with one of above pigments stirred into resin-solvent vehicle, baked, painted again with clear coat of vehicles and baked again. Decay curves detd. after excitation by 100-w. "Mazda" filament lamp or 100-w. "B.H. 4" high-pressure mercury vapor lamp. Long period decay in these phosphors is of bimolecular type. Compared with white traffic paint, found to have brightness of 0.12 microlambert or moonless, slightly hazy night when illumination from sky had brightness of 0.15 microlambert, Zn-CdS would reach 0.12 microlambert in 18 min., ZnS in 70 min., CdS in 3 hr. and SrS in 4 hr. Measurements agree with conclusion of British Bul. C-17: "With a good quality strontium or strontium-calcium sulfide, the performance to be expected in practice is that a marking will be usefully visible for perhaps 4 hr. after sunset on a moonless, starlight night. For several more hours, it may be discernibly brighter than similar marking of white paint, after which white paint is equally, if not more, efficacious, depending on the relative reflection factors and on the amount of light that is being received from night sky. Use of efficient phosphorescent paint will, however, ensure that markings are visible on those few really black nights when greatest difficulty in movement expected." In above expts., if partly cloudy sky reduced sky illumination 50%, phosphorescent pigments would be brighter than white paint for 30 min., 2 hr. and 6 hr., corresponding respectively to Zn-Cds, ZnS and CaS and SrS phosphors. Yellow traffic paint had brightness of 0.034 microlambert compared to 0.12 for white under same illumination, concrete pavement yielding same value as yellow paint. Rotating phosphoscope described for measuring short-period phosphorescence. Color of luminous materials important; red recognized as red over larger area than green or blue as green or blue; but over much larger area, green or blue seen as dazzling white light. Blue-green phosphorescent signs, however, likely to appear out of focus and hard to read, so that letters must be made large. Yellow or yellow-green easier to read even when seeming less bright. Even at very low illumination, blue-green appears glaring to dark-adapted eye. Hardy spectrophotometer adapted to measuring color of light emitted by phosphors. Complete luminescence resulted when ZnS or CaS painted on at rate of 44 sq.ft. per lb. For Zn-CdS, rate was 115 sq.ft. per lb. of pigment. Little known about durability under various conditions of use. Alk. earth sulfide phosphors, especially SrS type, rapidly decomposed by moisture and must be protected by clear top finish if even few months' service to be obtd. ZnS and Zn-CdS phosphors subject to light darkening, but otherwise highly resistant to weathering.—*Selma Gottlieb.*

Plastics Invade the Water Works Field. ANON. Can. Engr.—Wtr. & Sew. **80:** 9: 22 (Sept. '42). Development of plastic pipe progressed to point where early use for plumbing installations and certain special purposes in water works certain. Pipe now made in sizes up to 1.5" diam.; and mfr. of 6" and larger pipe predicted for near future. Costs falling rapidly as production increases; price lists cut almost 50% within past yr. Plant being equipped in Oshawa, Ont., for mfr. of all types of extruded plastics. Important advantages claimed for plastic pipe include: (1) freedom from corrosion; (2) no damage by repeated freezing and thawing within sealed pipe; (3) resistance to majority of acids and bases up to 10% concn.; (4) wt. of pipe of same diam. and wall-thickness is 18% of cast iron, 15% of brass and 11% of lead; (5) bending and jointing can be simply performed; (6) relatively thin-walled pipe has withstood bursting pressure of 3,000 psi; (7) age, sunlight and weather without effect; (8) high resistance to impact, shock and abrasion; (9) good elec. insulator; (10) high resilience and comparatively high flexibility; (11) heavy-walled pipe may be tapped and threaded; (12) pipe made in any desired color and in 10 different degrees of plasticity; (13) transportation only limit to length—smaller sizes of tubing coiled in 500' lengths. Joints can be made by use of std. S.A.E. flange-type couplings, by flaring for bell-and-spigot joints and calking with plastic solder, or by soldered sleeve couplings. Plastic solder made by mixing 1 part pulverized plastic and 9 parts acetone. Plastic pipe not recommended for working temp. higher than

180°F. One Canadian water works plans to try it for chlorine lines, as expts. have indicated that it is not affected by chlorine gas. Products of Oshawa plant will be of 3 base plastics: (1) cellulose acetate butyrate; (2) polyvinyl butyral; and (3) monomeric vinylidene chloride. Foregoing remarks refer to pipe made from type (1). Methods of mfr. and types of products outlined.—*R. E. Thompson.*

Bomb Extinguisher Devices. ANON. Neb. Munic. Review *No.* 218: 22 (Sept. '42) (From statement authorized by OCD Director JAMES M. LANDIS). Based on wide experience abroad and tests in this country, commercial powders, sand, talc, similar agents limited to use where little danger of serious fire. Many commercial powders tested, but none better than sand, dry dirt or ashes. Unless cost negligible, not recommended. Engender false sense of security. Water, with pump tank, stirrup pump or other water-type extinguisher most effective method of dealing with fire from bomb, or bomb itself. Water, therefore, primary agent for fire control. Scoop, grab and snuffer devices of no practical value for civilian use. Home-made equip. adequate in most cases.—*Ralph E. Noble.*

Testing Fire Engines. ANON. Neb. Munic. Review *No.* 217: 12 (Aug. '42). Nothing quite so important as condition of fire dept. app., particularly pumpers, for combating fires from incendiary bombs, one of principal war dangers. Recent tests showed many rotary pumps worn, slippage high, causing engine to run correspondingly faster to deliver rated capac. Higher speeds develop such troubles as burned out bearings, short circuits in magneto, broken connecting rods and overheating. To overcome danger, all modern pumpers equipped with engine-speed indicators. Addnl. factors to consider seriously: operators unfamiliar with all engine types; supply of relief operators; operator's unfamiliarity with various type relief valves and hence inability to detect bypassing; full knowledge as to effect of leaks in suction hose, in piping around pump and pump bearings. Important to test pumpers at least annually, in normal times. Imperative for civilian defense.—*Ralph E. Noble.*

FIRE PROTECTION

Supplementary Water Supply for Fire Fighting. W. E. C. CHAMBERLAIN. Wtr. & Wtr. Eng. (Br.) **44:** 144 (June '42). Once source of supply established, problem of ensuring that supply can be utilized at all times with min. delay arises. Pumps used for fire fighting are high-speed centrifugal types possessing great asset of being self-priming. Methods of drawing water from lakes, ponds, streams, etc. include: (1) submerge suction hose in water; (2) construct sump from which water may be pumped through strained suction hoses; (3) install a c-i. or steel suction main. Water from seashore may be obtained by running mobile pumps close to water's edge. Placing too much reliance on springs, wells and the like is a matter of chance. Pumping water from sewers impracticable. Basis of design for storage tanks include: suitability of site, economics of constr., stability of structure, watertightness, protection from bomb splinters, damage from earth shock, facility of repair, temp. effects, labor available, use of mechanical power in constr. and availability of materials. Brick and concrete semi-sunken type, with capacs. 30,000 to 50,000 gal. (Imp.), reinforced concrete type with capacs. 60,000 to 100,000 gal. (Imp.) and puddled clay type with capacs. 150,000 gal. (Imp.) and over have become standardized. Brick surface tanks developed to meet case of restricted sites or sites where embanked tanks would be at disadvantage, e.g., in school playgrounds. Principal feature of rectangular steel surface tanks in highways is utilization of carriageway itself as bottom of tank to economize in use of steel. Assurance of watertightness principal problem in tanks of this nature. Method of constr. of circular steel tanks fully covered by "Home Office" instruction. Advantage should be taken of potential storage capac. of basements and cellars of war-damaged bldgs. Knowledge of nature of subsoil in open spaces may also result in provision of small storage basins at little cost.—*H. E. Babbitt.*

Leeds Static Water Supplies. W. SLEIGHT. Surveyor (Br.) **101:** 345 (Oct. 9, '42). Sites for basins and tanks selected by Regional Works Adviser and Fire Force Commander to provide adequate and continuous water for fire fighting. Type adopted depended on several factors, such as: (1) size of site and

surface levels; (2) cover required; (3) bearing capac. of subsoil; (4) labor and materials available. Three general types of basins standardized: (1) dished with brick lining and wholly sunken; (2) dished with concrete lining and wholly sunken; (3) circular brick type, with concrete- or brick-paved base, wholly or semi-sunken. Tanks classified as: (1) rectangular steel, 5,000 gal. (Imp.) capac.; (2) circular steel, 11,000 to 22,000 gal. (Imp.) capac.; (3) rectangular stepped brick, 10,000 to 20,000 gal. (Imp.) capac.; and (4) brick-concrete, 10,000 to 20,000 gal. (Imp.) capac. —*H. E. Babbitt.*

Borehole Type of Pump for Fire Service. ANON. Wtr. & Wtr. Eng. (Br.) **44:** 61 (Mar. '42). River Thames being tidal up as far as Teddington—with variation of approx. 24'—use of std. shore fire equip. at low tide impracticable in many cases due to high suction lift. Stationary equip. mounted on floating platforms presented problem of maintg. supply lines without obstructing waterway. Most practical soln. borehole pump driven by gasoline engine through bevel gear unit and hydraulic coupling. Pump designed to have non-overloading characteristic which permits power developed by engine to be utilized to max. over considerable variations in head. Engine portion can be removed as whole and, in event of damage, can be replaced by separate unit.—*H. E. Babbitt.*

Additional Fire Protection Data. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **4:** B: 6: 18 (Feb. '42). Data given include: fire protection charges expressed as percentage of total water works revenue (which vary from 0 to 43%); addnl. amts. paid by municipality for water works (including operating deficits, debt retirements, etc.); surplus funds paid to municipality; and total munic. charges less surplus paid to municipality. Information given is for yr. '40. 111 Canadian municipalities included in tabulation.—*R. E. Thompson.*

Hydrant Spacing. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **4:** C: 9: 25 (May '42). Data regarding Canadian municipalities tabulated under following headings: no. of hydrants, no. of hydrants per mi. of mains, and spacing in residential and business dists. No. of hydrants per mi. of main varies from 4 to 24 and avgs. 8.5.—*R. E. Thompson.*

Control of Hydrants. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** C: 1: 1 (July '42). Data for Canadian municipalities tabulated under following headings: dept. responsible for inspection; notification by fire dept. when hydrants operated during winter; whether or not water dept. receives revenue for hydrant maint. other than from fire protection charges. In vast majority of cases water dept. responsible for inspection, fire dept. notifies water dept. when hydrants used, and fire protection charges only source of maint. revenue.—*R. E. Thompson.*

Opening of Hydrants. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** C: 3: 10 (July '42). Tabulated data for Canadian municipalities shows to whom permission to open hydrants given other than fire and water dept. employees, restrictions imposed regarding opening by other than these employees, and practice in regard to systematic flushing of hydrants.—*R. E. Thompson.*

Fire Hydrants—Inspection and Testing. *Revised Instruction, Fire Brigade Dept. of Ministry of Home Security.* Wtr. & Wtr. Eng. (Br.) **45:** 186 (Nov. '42). Procedure agreed upon with British Water Works Assn. that Fire Force Commanders will see that satisfactory arrangements are made for liaison with water undertakings. Hydrants to be inspected at least twice a year and, where personnel permits, four times per year. At one of the inspections, each hydrant to be tested by: (1) ascertaining that thread is in good order; (2) working spindle in case of sluice valve hydrants and working valve in ball valve hydrants; (3) removing blank cap and operating valve to release small quant. of water through hydrant to ascertain if it is charged after full valve operation; and (4) inspecting frost valve carefully to see that it is in satisfactory working order. After each inspection, test or use, hydrant pits are to be left empty and clean. Normally necessary to run flow tests only in case of mains of 6" in diam. or less and where main is of some length. Results of tests or inspections to be recorded in hydrant book.—*H. E. Babbitt.*

Maintenance of Hydrants. A. E. BERRY. Can. Eng.—Wtr. & Sew. **80:** 3: 19 (Mar. '42). Replies received from 100 Canadian municipalities to questionnaire distrd. by Can. Sec. A.W.W.A., tabulated, analyzed and discussed.

Hydrant rental, so-called, basis of fire protection charges in 66 communities, lump sums paid in 18 instances, fire protection included with other charges in 3 municipalities, and in substantial no. of cases no charge levied. In '40, avg. hydrant rental charge in 86 municipalities in which any form of fire protection charge levied was $37.85, lower than generally considered fair. Charges avgd. 73.4¢ per capita. In '41, avg. cost of hydrant maint. in 75 communities was $4.57. Winter servicing accounts for considerable part of maint. in Canada and costs of $7–10 frequently occur in centers where winter severe. No. of hydrants per mi. in many cases falls within range of 5–8. Frequency of painting varies, but 2-yr. interval appears to be common practice. In 82 communities, painting done by water works depts.; in others, work carried out by contract, by munic. employees, or by fire depts. Frequent inspection chief means of winter protection. Draining to sewer where available and use of gravel at base of hydrant has wide acceptance. Pumping out the barrel practiced in no. of places. In normal winter, no. of frozen hydrants surprisingly small. In summer, inspections made monthly in no. of places, while during low temp. periods daily inspection frequently the rule. In most municipalities, water works dept. makes inspections, but in some they are carried out by fire dept. alone or jointly with water dept. Party responsible for traffic damage to hydrants liable in most centers, if he can be apprehended. Use of shut-off valves on all hydrant connections by no means universal, but this std. is objective in no. of places. Practice of permitting contractors and others to use hydrants, except under special restrictions, has not found much favor. Regular flushing of hydrants reported in 52 municipalities. In limited no. of places, steam boilers or other thawing apparatus sent to all winter fires, and there appears to be tendency for water dept. to exam. all hydrants carefully as soon as fire extinguished. Member of water dept. attends all fires in some communities.—*R. E. Thompson.*

Hydrant Maintenance Cost, 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **4:** B: 7: 22 (Mar. '42). Data regarding cost of hydrant maint. in 75 Canadian municipalities during '41 tabulated under following headings: no. of hydrants, total cost, cost per hydrant. Latter varied from $0.20 to $13.30 and avgd. $4.57.—*R. E. Thompson.*

Painting of Hydrants. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **4:** C: 10: 30 (May '42). Procedures followed in Canadian communities listed under following headings: color, no. of coats of paint, cost per hydrant, by whom performed and frequency. Cost of painting ranges from $0.12 to $2.00 per hydrant.—*R. E. Thompson.*

Thawing of Hydrants. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** C: 2: 5 (July '42). Tabulation of practice in Canadian communities in regard to hydrants found out of commission at time of fire. Data tabulated under headings: sending of thawing app. on receipt of fire alarms during extreme weather; how soon action taken in regard to thawing hydrants reported frozen by fire dept.; by whom thawing operations carried out.—*R. E. Thompson.*

U.S. WATER SUPPLIES—GENERAL

Industrial Quality of Public Water Supplies in Georgia, 1940. WILLIAM L. LAMAR. U.S. Geol. Survey Water-Supply Paper No. 912 ('42). Information on chem. characteristics of pub. water supplies essential to location of many indus. and to better and more economical water use by indus. and domestic consumers. 66 pub. supplies described serve 1,098,819 total pop., 35.2% of state pop. Nearly all water for half of these supplies from surface sources; half from ground. Practically all surface supplies in Appalachian Highlands, nearly all wells in Coastal Plain. Surface sources serve 759,784, ground sources, 339,035 consumers. Larger no. of people in state use ground water, as nearly all individual supplies therefrom. For each pub. supply, data given on ownership, source, treatment, storage and distr. 157 complete mineral anals. show chem. of water at each. Where water receives chem. treatment other than chlorination, anals. given for both raw and finished. Some variation in surface water compn. during yr., but generally mineral content low. In only few surface supplies max. concn. of dissolved solids exceeds 100 ppm. Total mineral content for all but few ground waters generally 100 to 200 ppm. Exceeds latter in some cases. Extreme values, 24 and 1,030 ppm. Si and bicarbonate represent more than half of mineral content of raw surface waters. Alum in coag. of surface

waters increases SO_4 at expense of bicarbonate, but usually latter brought back or increased by final adjustment of pH. For many ground waters, Ca- and Mg-bicarbonates and Si make up nearly all of mineral matter. Some well waters, particularly in southern and southeastern Coastal Plain, also contain appreciable SO_4. Surface water anals. show raw waters contain little Fe, most of which removed in treatment. As coagd. surface waters generally corrosive, however, treated waters would dissolve Fe from mains and service pipes but for fact that most have final pH adjustment to inhibit corrosion. Ground water anals. show that, generally, when sufficient Fe or Mn present to cause trouble, it is removed by treatment. Only few ground waters, as supplied to consumers, corrosive enough to dissolve troublesome quants. of Fe. Most stream sources for larger pub. supplies in Ga. yield soft water at all times. Ground waters generally appreciably harder than surface ones, most ranging from 60 to 200 ppm. Extremes, 12 and 621 ppm. Hardest contain, in addn., some noncarbonate hardness due to $CaSO_4$. Largest no. of persons receive water of 1 to 60 ppm. hardness. Of 66 pub. supplies, avg. hardness of 33 surface ones, 29 ppm.; of 33 ground water ones, 123 ppm.; for all, 77 ppm.—*Ralph E. Noble.*

Turn on the Water. J. F. SCHAFFHAUSEN. Country Gentleman **112:** 8: 11 (Aug. '42). Author describes running water systems used advantageously in hog-raising and dairy work. Jet or ejector type of deep-well pump relatively new, simple and of high capac. under low pressure; suitable for depths up to 120'; does not require installation over well, or lubrication. Plunger type most common deep-well pump, drawing water from 400' to 500'. Local conditions and availability of elec. determine pump type best suited for needs. Windmills pump more water than any other power source at low cost service if well installed and maintd. Large storage capac. required, however, to tide over calm periods. In addn., portable gasoline engine desirable for fresh water and emergency pumping. Where feasible, gravity water system superior to any other because constr. and operation simple. Spring developed by excavating close to point issuing from ground, down to bed rock, unless adequate supply afforded on clay or gravel foundation. Tight cover essential to exclude trash and animals and to prevent bailing and dipping. Slow flow requires storage reservoir. Must balance cost of latter and pipe against cost of pump. Pipe size detd. by distance from spring. Usually more than 1" diam. Farmers Bul. No. 1426 best ref. for data on discharge of ¾" to 4" water pipes of various lengths and falls. Gasoline and diesel engines well suited to farm pumping and equipped to stop at any pressure in tank supply. Elec. pumps more convenient, of course. No farm water system constructed without: (1) calcg. peak requirements in terms of gpd. use per person and per unit of stock; (2) allowing for sprinkling and fire fighting needs; (3) estg. future expansion plus safety factor of 10 to 15%. System should be large enough to pump this quant. 2 to 3 hr. per day, to reduce wear on moving parts to min. Water sources should be checked as to adequacy and safe quality. Equip. should be inspected, repairs and replacements made often enough to maint. best eff. Should inspect oil in pump and motor at least every 3 mo.; change oil once or twice a yr. Pit pump inspected more frequently to see that oil not flooded from gear-case or housing.—*Ralph E. Noble.*

Water and Community Growth in Utah. RALF R. WOOLEY. Civ. Eng. **12:** 500 (Sept. '42). Each of early settlements of state had beginning along banks of small stream, usually on fertile alluvial fan built by stream on leaving canyon. Salt Lake City had beginning along banks of City Creek. City of 150,000 people now has more than 390 mi. of water mains and more than $13,000,000 invested in water works. During decade ending in 1890, city's pop. increased more than 115% and sources of water supply in use became inadequate. Water problems incident to growth of Salt Lake City not unique. Ogden had similar experiences. Urban communities of state have not been alone in water supply troubles. Rural settlements have been facing increasing difficulties. In Jordan Valley, Utah, "farm village" is community of people residing in relatively compact area and cultivating farms adjacent to village. Since limit of many water supplies reached, irrigation and agric. expansion no longer possible. New industries in Great Salt Lake Valley stimulating pop. growth and increasing economic opportunity. Emergencies often change economic pattern of region by shifting industry, and some such changes may carry over into stabilized new pattern.

Realization of such possibilities for Utah depends on water supply situation in local areas. —*H. E. Babbitt.*

Water Supply for the East Bay Cities. J. S. LONGWELL. Western City **18:** 10: 22 (Oct., '42). East Bay Munic. Utility Dist. supplies water to Oakland, Berkeley, Richmond, Alameda, San Leandro, Piedmont, El Cerrito, Albany, Emeryville, Calif.; to large adjacent unincorporated area, including 5 county water dists.; to many large rural residential developments; to Army-Navy bases, camps, training centers and several large indus. in war effort. Avg. water used, 53.3 mgd. in yr. ending June 30, '42, 15% increase. On July 1, '42, no. of active services 157,148 compared with 70,424 in '21. Mokelumne R. main source. District's largest and most important storage unit Pardee Reservoir (68 billion gal. capac.) near Stockton. Water transmitted through 65″ pipe of 70 mgd. capac. Diversion works and tunnels designed for ultimate 200 mgd. 4 addnl. terminal reservoirs near Oakland and Berkeley have combined capac. of 33 billion gal., of which part supplied by own watersheds, bal. from Mokelumne R. Combined capac. of 5 filtration plants nominally 75 mgd., but with pre-treatment capable of 50% overload. San. patrols maintd. on all watersheds. 2 labs. make bact. and biol. tests of samples from entire sys. Reservoirs $CuSO_4$-treated when necessary. Lime added for corrosion control; Cl_2 for disinfection and bact. control; alum for coag. in pre-treatment works when turbidity high. Activated carbon equip. available. Distr. sys. consists of 1,800 mi. of 2″ to 54″ diam. pipe. Major output by gravity, but 46 distr. pumps serve 1,500′ el. All pumping plants elec.-operated and automatically controlled from storage points served. Distr. storage provided by concrete-lined reservoirs, concrete, steel and redwood tanks totaling 320 mil.gal. capac. described. District's services to consumers 100% metered. Meter efficiency check, maint. and repair described. Tests definitely show measurement accuracy seriously affected by piping layouts ahead of meters and resulted in developing std. practices for layouts of all such installations. Reduction in losses of metered consumption to consumers effected by steady program of replacing old, worn out mains and prompt repair of leaks. Emergency protection measures described. Dist. co-operates closely with civilian defense activities. —*Ralph E. Noble.*

San Diego Faces 1960's Problems Today. ANON. Eng. News-Rec. **129:** 110 (July 16, '42). Pop. of San Diego increased from 202,000 in '40 to approx. 350,000, and munic. problems increased accordingly. City's water supply derived from impounded storage in 5 reservoirs located 6 to 40 mi. from city on 3 river systems—Cottonwood-Otay, San Diego and San Dieguito. Safe yield of extreme importance as major runoffs that will fill reservoirs occur only once in 10–11 yr. Three reservoirs on Cottonwood-Otay have total safe yield of 13.6 mgd., which is delivered to 13-mgd. filter plant at Savage Dam and thence 19 mi. to balancing reservoir at University Heights. Water from reservoir on San Dieguito R., which affords safe yield of 3 mgd., passes through filter plant at north city line and thence into distr. system. El Capitan Dam on San Diego R. has safe yield of 10 mgd., delivered through 25-mi. line to reservoir and 16-mgd. filter plant at University Heights. Total safe yield therefore 26.6 mgd., while consumption has been as high as 46 mgd. and monthly demand consistently 40–50% over last yr., which equaled or exceeded safe yield. All 5 reservoirs filled to spillway, however, and supply sufficient for 3 yr. even if no rain should fall, and, on basis of past experience, yr. of major runoff should occur near end of 3-yr. period to replenish supply. To augment supply, city had choice of bringing in Colorado R. water or of starting development of few remaining local sources. City and county entitled to 100 mgd. from former, which can be obtained either by bldg. 78-mi. conduit from aqueduct serving Los Angeles Metropolitan District or by constructing 96-mi. conduit and tunnel from westerly end of All-American Canal across mountains in Imperial Valley. Four-part development of local sources would add 25.2 mgd. to present safe yield. One of parts, $3,550,000 dam on San Vincente Creek, which will provide 5-mgd. safe yield, being rushed to completion for Feb. '43 completion date to catch tail end of any winter runoff. Structure straight concrete gravity section dam, 950′ long at crest and 200′ high, and reservoir formed will have capac. of 75,000 acre-ft. Dam being constructed at faster rate than highway in valley can be relocated and 22 x 20′ opening being left in dam to accommodate road temporarily. Colorado R. project cannot be postponed much longer. Alternative is to court disaster in event of repetition of 1897–1904 drought.

when there was practically no runoff from local drainage areas for 7 consecutive yr. In addn. to augmenting supply system, 6 major projects under way to improve inadequate distr. system, including booster station and large supply mains. Other civic improvements include sewage treatment plant and intercepting sewer which will clear bay of raw sewage outfalls.—*R. E. Thompson.*

First Colorado River Water Delivered to Southern California Cities. WILLIAM W. AULTMAN. Western City. **17:** 7: 18 (July '41). Softened and filtered Colo. R. water first delivered on June 17, '41 to Pasadena and others of 13 member cities of Metropolitan Water Dist. of S. Calif. Water taken from river 300 mi. away, financed by $220,000,000 bond issue. Softening plant located about 30 mi. east of Los Angeles, plant has initial capac. of 100 mgd., with later possible expansion to 400 mgd. Avg. hardness of Colo. River water 300 ppm. consisting of $Ca(HCO_3)_2$, $CaSO_4$ and $MgSO_4$, to be reduced to about 85 ppm. Lime and zeolite methods used. Provisions made for 3 dry feeders for lime, and 2 for coagulant, soda ash or other chems. Phosphate and $(NH_4)_2SO_4$ fed in soln. from tanks on third floor of head house. CO_2 obtained from gas or oil, possibly later from reclamation process of lime, activated carbon feed and storage kept away from main plant. Flash mixing and flocculators used for mixing. Flocculator basins rated at 50 mgd. with ½ hr. flocculating period and 2-hr. settling period. Filters of conventional type, after filtration required proportion (to give effective hardness of 85) of water softened by zeolite to zero hardness, the 12 zeolite units like filters with up-flow operation. Each bed contains 2,200 cu.ft.; operates between 6 and 8 gpm. per sq.ft. Design based on use of synthetic gel-type zeolite with operating exchange value of 9–11,000 grains hardness per cu.ft. and salt consumption not to exceed 0.35 lb. salt per 1,000 grains hardness removed.—*Martin E. Flentje.*

40th Annual Report, Board of Water and Power Commissioners of the City of Los Angeles. Report for year ending June 30, '41 lists detailed activities of Bureau of Water Works and Supply and Bureau of Power and Light. Gross income of water dept. amtd. to $12,844,955; net, $3,110,910—decrease of $873,852 in spite of gross increase of $135,043. Due principally to completion of Mono Basin project requiring increased provision for depn. and cessation of interest charges to constr. Total income Power and Light Dept. $32,524,165—increase of $2,350,709 over previous yr. Since acquisition of privately owned Los Angeles Water Co. in '02, with its water supply in the Los Angeles R. watershed, plant has been extended in '08–'13 by bldg. of Owens River Aqueduct; providing water resources sufficient for pop. of 2,000,000, from eastern slope of Sierra Nevada Mts.; extension of this system by Mono Basin project just completed; utilization, by '17, of aqueduct flow to generate elec.; first bldg. of elec. distr. lines in city in '16; purchase of distr. system of electric co. in '22; taking power from Boulder Dam since '36 and purchase of generating and distr. system of L.A. Gas and Elec. Corp. in '37. Total assets of water bureau have grown from $136,759,980 in '32 to $184,077,342 in '41. Of '41 figure, plant and property equal $177,012,676 and depn. reserve $33,989,430 (19.2%). Bonds and long term notes outstanding equal $65,364,899. Gross revenue (including non-operating) for '41 was $13,288,788; operating expenses and taxes were $4,727,422. Operating ratio equaled 35.7%, interest cost was 19.7% of gross; depn., 20.2%; taxes, 2.1%; maintenance, 10.3%; transfers to city funds, 4.44%. *Los Angeles Aqueduct:* Mono Basin Extension completed and turned over to this div. on Jan. 2, '41. During yr. aqueduct shut off in one section or another for total of 4,454 hr.—one period for 63 days. Portions of 5 steel siphons on aqueduct, originally constructed of ¼″ and $\frac{5}{16}$″ riveted pipe, replaced with ⅜″ welded steel pipe (*see* Jour. A.W.W.A. **34:** 1635 ('42)). *Aqueduct Hydrography:* Div. measures flows of streams, observes climatic and related matters, etc. Pptn. in regions from which water supply drawn were 7.09″, 8.02″, 15.35″ and 32.76″ as against 3.46″, 4.47″, 5.46″ and 19.21″ for same stations for previous yr. and normal of 6.08″, 4.87″, 5.63″ and 15.23″. Water spread totaled 259,477 acre-ft., and reservoir storage amtd. to 100,065 acre-ft. on June 30, '41. *Water Distr. System:* Unusual demand for new housing resulted in many extensions of distr. system, among which were: 53,441′ of 60″ welded steel pipe, 5300′ of 52″ welded steel pipe, and 21,700′ of 48″ pipe; placement of seven 36″ and six 30″ rotary cone valves; two 48″ and one 30″ square-bottom gates; one 24″ and one 16″ std. gates; nine 6″ simplex air valves, etc. Studies of corrosion of internal parts of

meters carried on. Of historic interest was installation of 300,000th meter on Jan. 9, '41. Total meters in service equaled 302,241, increase of 11,670; of these 76,917 are $\frac{5}{8}$"; 141,771, $\frac{5}{8}$" x $\frac{3}{4}$"; and 49,983, $\frac{3}{4}$" x 1". Of meters removed for non-operation, 975 (22.8% of total brought to shop) damaged by hot water, and 4939 removed for minor repairs. Unit cost per meter repaired for shop expense was $5.02, made up of $2.84 for labor (2.62 hr.), $2.05 for material and $0.13 for warehouse and tool expense; testing expense was $0.14 per meter, field expense was $4.23; avg. total cost per meter repaired was $9.38. Avg. maint. cost per meter in system was: for shop expense, $0.209; for field expense, $0.168; total, $0.377. Total service connection pipe in system 6,600,044', of which 307,469' installed in yr. and 100,978' abandoned. 2631 leaks repaired in steel mains, 319 in c-i.; 1791 minor repairs made on fire hydrants and 234 broken hydrants repaired. Of c-i. pipe failures, 48 caused by graphitization, 25 by settlement of ground, 2 by water hammer, 19 unknown (total, 119). Considerable water used for irrigation; total planting irrigated equaled 30,774 rotated crop acres of which 10.03% was in alfalfa, 34.54% in citrus and 28.20% in misc. truck. Total water revenue from this, $417,159. *Design and Drafting:* Distr. system has total of 4189.8 mi. of distr. mains (4"–78"), net increase of 70.2 mi. Of this total, 3278.0 mi. is c-i. pipe. System has total of 21,400 fire hydrants and 50,279 gate valves (4"-54"). Mean domestic water consumption 175 mgd., with summer mean of 203 mgd. and winter mean, 148 mgd.; peak (July 8–15) 244 mgd. Rainfall 32.76", 115% above normal. Estd. pop. served, 1,468,400; per capita consumption, 119 gpd. *San. Eng. Div:* Lab. conducted 48,176 anals.; and over 25,000 field detns. of rel. Cl, turbidity, etc., made. Bact. samples collected from 148 regular sampling points, mostly house taps. As in past, san. chem. anals. demonstrated ability of long storage to improve water qual.; detention in 60,000 acre-ft. Haiwee Reservoir resulted in 28% reduction in total N, 21% in O consumed, 37% in color and 86% in turbidity. Of 1340 bact. samples from reservoir inlet, 367 tubes positive, only 9 positive at outlet (54% at inlet and 1.36% at outlet). Little variation in mineral content of water over previous yr., most signif. being increase in total hardness from 108 to 124 ppm. in aqueduct supply. Satn. index of entire supply increased slightly during yr. assuring maint. of relatively non-corrosive water throughout city. Weighted avg. of city supply, results of mineral analyses (in ppm.) include: Ca, 43; Mg, 14; total hardness, 163; Na, 46; K, 5; Alk. CO_3, 14; HCO_3, 141; SO_4, 74; Cl, 23; SiO_2, 20; Fe, 0; pH, 8.1; satn. index, +2.6; temp., 18°C. Yr. very difficult one from standpoint of algae control in reservoirs, these being treated 57 times, July and Apr. being months of heaviest treatments. Over 63% of 115 tons $CuSO_4$ used employed to destroy green and blue-green algae and 34% for diatoms. Reversal of previous experience. Avg. Cl dose for yr. 45% greater than '39–'40. Avg. reduction of *Esch. coli* for all Cl stations avgd. 96.0%; avg. *Esch. coli* count of treated water, 0.14 per 100 ml. 7098 water qual. complaints recd.; no. of complaints of alleged sickness 2.5%, with none found actually traceable to water on investigation. Report gives details of activities of other divs. including those of elec. dept. Exceptionally well printed, arranged and illustrated with graphs, maps and splendid photographs.—*Martin E. Flentje.*

60th Annual Report (1941) of the Board of Water Commissioners, St. Paul, Minn. St. Paul water dept. administered by elected board of three comrs. Pop. of city (estd.) 289,200; estd. pop. on pipelines 287,000. Book value of property on Dec. 31, '41, $19,810,826; net bonded debt, $4,538,569. Total revenue during yr. from sale of water equaled $1,017,994; total income all sources, $1,197,865; net operating income, $120,578. Revenue per mil. gal. pumped, $125.25 (exclusive of frontage tax receipts) which compares with 10-yr. avg. of $119.80. Various costs for (1) '41 and (2) 10-yr. avg. follow: (all per mil.gal. pumped): admin. costs (1) $13.78 (represents 25.25% of all operating costs), (2) $15.24; production costs (1) $19.50 (35.73%), (2) $15.25; distr. costs (1) $21.30 (39.02%), (2) $22.12; interest costs (1) $30.60, (2) $33.65; sinking funds and serial bond retirements (1) $20.51, (2) $21.08. Percentage distr. of all costs given: salaries and wages, 31.13%; heat, light and power, 9.31%; chem. supplies, 4.23%; other supplies and expense, 9.59%; interest charges, 27.38%; sinking fund, 6.01%; serial bonds, 12.35%. 8,566 mil.gal. delivered to system for sale, 11.17% unacctd.-for. Avg. consumption of 24,482 mgd. equals 84.3 gpd. per capita, 361.3 gpd. per live tap (99.9% of accts. metered). Domestic consumption 57.8% of total, 42.2%

commercial. Max. day's consumption 54.039 mgd. Distr. system has 643.89 mi. of mains in use, 13,586 added during yr.; cost of repair and maint. per mi. of system, including hydrants, st. work, etc., $47.96. Hydrants total 5,411, avg. maint. cost per hydrant, $3.06. Range in pressure, 30 to 120 psi. No. of live accounts equals 67,506—89 of which flat rate. Pop. of city per mi. of paved and graded sts., 423; per mi. of main, 465. Total water pumped at all low service stations equaled 9,039 mil.gal. for yr. at total cost of $44,073.63, divided (per mil.gal.) $3.57 for power, $1.06 for labor—$4.63, total operation —$0.25 for total maint.—$4.88 total. Water softened by lime-soda process; cost for chem. in '41, $4.73 per mil.gal. as against cost of coagulation alone, in '38, of $2.83. Chems. used and avg. rate of treatment per mil.gal. for yr.: alum, 8.80 ppm.; ammonium sulfate, 0.16 ppm.; liquid Cl, 0.81 ppm.; lime (CaO), 107.50 ppm.; phosphorus as phosphorus anhydride, 0.092 ppm. Cost per mil.gal. for above in order given: $0.91, 0.07, 0.18, 3.55, 0.02. Avg. turbidity plant influent 3 ppm.; bacteria per ml. at 37°C., 260; colon index, 4.23. Turbidity plant effluent, trace; bacteria, 13; colon index, tr. Avg. total hardness: raw, 176; effluent, 89 ppm. Filter wash water percentage equaled 1.58%.—*Martin E. Flentje.*

84th Annual Report (For Year Ending December 31, 1941), Louisville (Ky.) Water Co. Report covers most profitable yr. in history of company. Total revenue equaled $2,293,457, increase of $121,571. Increase due mainly to better business and increase in percentage of acctd.-for water (3.92% over '40). Net profit for yr. $1,156,339; largest in history of co. and attributable to increased revenue and to marked decrease in operating costs. In Dec., dividend of $1,000,000 declared to Sinking Board Fund and later increased by an addnl. $121,634. Outstanding bonds of co. continue to be $1,000,000, with retirement reserve on hand of $786,785. Total operating fixed capital at end of yr. equaled $21,229,371, with total fixed capital of $21,577,784. Pop. of city and county estd. as being 350,000. Original water works constructed in '80, owned entirely by city and managed by Board of Water Works. Source of supply Ohio R. Water pumped to reservoir and repumped to mains after purif. Total pumpage, Riverside Pumping Sta. (to res.) 17,011.37 mil.gal., at Crescent Hill Pumping Sta. (to system), 17,004.44 mil.gal.; avg. pumpage, 47,040 mgd. Cost of pumpage at Riverside Station per mil.gal. for steam and elec. combined equals $6.135 per mil.gal. (elec. pumping normal with steam as standby); cost per mil.gal. raised 100′, $3.115. Total pumping cost Crescent Hill Station, $6.44 per mil.gal.; cost per mil.gal. raised 100′, $4.665. '41 total cost of purif. per mil.gal., $5.577, made up principally of: $0.67 for supervision; $1.36 for operating labor; $1.66 for chems.; $0.48 for wash water; $0.25 for heat, light and power. Avg. length of filter runs: South Filters, 40.05 hr.; North Filters, 40.05 hr. Wash water (including surface wash) equaled 2.57% of total filtered. Avg. chem. dosage in gpg. filtered: alum, 0.59; pebble lime, 0.298; in lb. per mil.gal. filtered: Cl, 11.35; ammonium sulfate, 3.90; activated carbon, 18 (used intermittently). Results of detns. for (1) 37°C. count, (2) coliform organisms per 100 ml., (3) turbidity and (4) alky., avgd: *river water* (1) 1643, (2) 1388, (3) 55, (4) 45; *settled water* (1) 929, (2) 329, (3) 34, (4) 45; *coagulated water* (1) 444, (2) 58, (3) 4, (4) 41; *filtered water* (1) 2.02, (2) 0, (3) 0, (4) 48. Total hardness filtered water, 130 ppm.; pH, 8.3; Cl, 29; residue on evapn., 246. Consumption of water equal to 127 gpd. per capita and 612 gpd. per active service. Metered accts. (active) numbered 72,902 of which 3714 were commercial and 665 industrial. 723 mi. of main in distr. system included pipe from 1″ to 60″; pressure range, 45 to 100 psi. Services 100% metered.—*Martin E. Flentje.*

Public Water Supplies and Control of Stream Pollution in Ohio. F. H. WARING. Ohio State Univ. Studies Eng. Series. **10:** No. 5 (Sept. '41); (Expt. Sta. Cir. No. 41). Ohio admitted to Union in 1803 with pop. of 45,365, increased to 230,760 by 1810. Cincinnati first municipality in Ohio to install public water supply system (in 1821), pop. of city then 9,600. First time Ohio R. water used for public use, entire water works constructed of wood and pumps operated by horses or oxen working circular treadmill. Second installation made in 1835 in Steubenville and third at Lisbon in 1840. In 1870 only 11 public water supplies existed, served pop. of 379,711 of state's entire 2,665,260 (14%). By 1890 supply works had increased to 78 serving 38% of state's pop.; in 1900 supply works numbered 172 and percentage of pop. was 49.6; in '10 figures had increased

to 237 and 58.9%; and in '40 to 416 and 71.9%, with state's pop. 4,962,300. Undesirability of untreated surface water for public use recognized at early date. Large dug wells using infiltration first used in 1870, artificial filtration (without coagulation) first tried at Columbus and Toledo in 1873–74. Both installations unsuccessful and quickly abandoned. Coagulation and pressure filtration installed at Bucyrus in 1887. First gravity filters used at Warren in 1895. Considerable impetus given to construction of purif. works in state by publication of results of purif. study and investigation at Cincinnati in 1896–97. No. of purif. and softening plants in Ohio approx. doubled in each of last 5 decades, (1) number of plants and (2) pop. served for 6 ten-year periods beginning 1890 and ending in '40 being, respectively: 2, 10,800; 6, 48,500; 22, 952,000; 46, 2,228,000; 83, 3,536,000; 167, 3,918,500 ('40). 57% of entire state's pop. served by purified or softened munic. treatment plants. In '20 only 3 (7%) of state's plants softened water; in '40, 67% softened. First munic. sewage plant in state constructed at Canton in 1893; in '40, 175 incorporated municipalities had plants. Effect of water purif. shown on typhoid fever death rate; accurate records kept at Cincinnati since 1885. In that yr. typhoid death rate in Cincinnati over 140 per 100,000, between then and '07 (when purif. plant started) rate avgd. 50 per 100,000; since has avgd. near 2 per 100,000 and in recent years has been under 1. Same trend in all other Ohio cities installing purif. plants; typhoid fever death rate for state has decreased from about 28 (per 100,000) in '10 to 0.78 in '40. At East Liverpool, special study has shown installation of purif. plant followed by 65% decrease in deaths from all causes of children under 5. Historical and statistical summary of Ohio public water supplies given in considerable detail, with same information for sewage disposal plants.—*Martin E. Flentje.*

Toledo's New Lake Erie Water Supply. GEORGE N. SCHOONMAKER. Civ. Eng. **12:** 316 (June '42) (*see also* Civ. Eng. (Br.) **37:** 191 (Sept. '42)). 1941 records show that 73,289 connections serve total pop. of 328,000 in Toledo and environs. Avg. daily pumpage for '41 was 40 mgd. Hourly pumping rate reached, at times, max. of 91.5 mgd. Nominal capac. of Maumee R. works 56 mgd. City decided by popular vote of $3,600,000 bond issued in Aug. '38 to abandon Maumee R. works and to construct entirely new system using Lake Erie as source. First constr. on Erie project started in Apr. '39. Project consists of following major elements: intake crib and conduit; raw water or low-service pumping station; Lake Erie pipeline; 80-mgd. filter plant; 35-mgd. covered concrete filtered-water reservoir; high-service pumping station; 1.0-mil.gal. elevated storage tank; and 7 mi. of large-diam. high-service trunk lines. Total of $9,884,463 expended in constr. of project, of which city contributed 55% and federal govt., through PWA, remaining 45%. Project substantially completed in summer of '41.—*H. E. Babbitt.*

Glass Features Construction of Toledo Filtration Plant. ANON. Am. City. **57:** 2:40 (Feb. '42). Because Lake Erie raw water for Toledo, Ohio, ½ as hard, more uniform in qual., unlimited in quant. and contains $\frac{1}{10}$ poln. load, Maumee R. source abandoned when new filtration plant completed in '41. Costing about $10,000,000, system consists of intake crib, 12′ diam. conduit, low-lift elec. pumping station and conduit, 80-mgd. filtration plant, storage reservoir and high-lift pumping equip. Besides extensive use of structural glass in plant, black Glastone used on filter control tables, corridors, stairways and lobbies. Heat-absorbing clear window glass used in lab.—*F. J. Maier.*

Dual Water Supply for Oklahoma City. ANON. Eng. News-Rec. **128:** 788 (May 7, '42). Details given of $6,900,000 improvement of existing water works and constr. of new 40-mgd. dual supply. Failure to obtain bids within allotted cost range resulted in decision to carry out earthwork and riprap for dam, canal and siphon by force acct., estd. saving by this procedure being $800,000. Major constr. items include: (1) 4-mi. earth dam 10 mi. northeast of city on Bluff Creek, tributary of Cimarron R.; (2) 5.5-mi. canal and 3,500′ reinforced-concrete box siphon to carry North Canadian R. water to new Bluff Creek Reservoir; (3) new treatment and pumping plant; and (4) 5 mi. of 48″ c-i. main to connect Bluff Creek Reservoir with existing distr. system. North Canadian R. project found most economical scheme for addnl. supply. Affords excellent soft water if storage filled at proper time. Old treatment plant, treating North Canadian R. water stored in L. Overholser, heavily overloaded. New treatment plant will provide similar

treatment, namely: (1) pre-chlorination (20-min. period); (2) addn. of alum and lime after 4-min. flash mix with return sludge; (3) 30-min. detention in flocculators; (4) 1-hr. settlement in clarifiers; (5) filtration through anthracite coal filters at rate of 4 gpm. per sq.ft. Addnl. plant will increase capac. from 16 to 32 mgd. On occasion, old plant has been operated at 24 mgd.—*R. E. Thompson.*

Utilizing Old Equipment to Modernize a Water Plant. ANON. Am. City. **57:** 6: 48 (June '42). Well water for Coopersville, Mich., contains 750 ppm. hardness, substantial part being iron. Former zeolite softening equip. failed to reduce hardness below 170 ppm. and capac. of filters had been reduced 50%. Plan for purchasing unfiltered L. Michigan water from Grand Rapids too expensive. By using old horizontal pressure filter tanks as vertical greensand zeolite softeners, former filters and softeners could be eliminated. Brine tank made from part of former softening tank. Improved piping arrangement permits elevated tank to float on mains rather than on filters. With these changes at $\frac{1}{10}$ cost of that estd. for alternate supply, water of zero hardness with better distr. obtained with use of no vital war materials.—*F. J. Maier.*

An Impounding Reservoir Supplants Artesian Wells. FRANK E. GUHIN. Am. City **57:** 5: 61 (May '42). Water supply for Aberdeen, S.D. (pop. 17,000) obtained from five 1,300′ artesian wells. System required continuous pumping, water very high in iron, very hard and ground water table continuously lowered. To replace source, 1,400′ dam constructed on Willow Creek impounding 1.3 bil.gal. on 850 acres. Filtration and softening plant includes rapid mixing basins, flocculators, lime feeders, settling basins, CO_2 generator, 4-mgd. capac. filters, wash water tank housed in plant and pumps. A 0.5-mil.gal. elevated storage tank eliminates any night operation.—*F. J. Maier.*

Shallow Lake Supply Supplemented by Wells. ANON. Am. City **57:** 3: 50 (Mar. '42). Watertown, S.D., uses 5,000-acre Lake Kampeska (12 to 15′ deep) as primary source and four 30″ wells when lake is drawn down, when excessive algae occur or when slaughter houses seasonally demand more water. System consists of low- and high-lift pumping stations, aerator, chem. feeders, sedimentation basins, 1½-mgd. capac. filters, clear well and standpipes. 100% metering reduced consumption to avg. of 76 gpd. per capita in winter.—*F. J. Maier.*

Development of Stoughton's [Mass.] Water Collecting System. L. MORRILL. J.N.E.W.W.A. **55:** 206 ('41). Development of water supply for Stoughton, Mass., reviewed. In 1892 supply insufficient and of poor quality, and Muddy Pond, which covers about 18 acres and is shallow, selected as new source of supply to serve 10,000 people. Fire which spread across Muddy Pond gathering ground hardened ground so that muddy surface water ran down into basin; between '36 and '38 color of water in Muddy Pond increased from 18 to 120 ppm. Temp. of water in pond became high in summer and growths of algae and weeds caused tastes and odors in water. In '39–40 gravity line and infiltration gallery constructed to obtain water direct from the springs feeding Muddy Pond. Results satisfactory, but as demand for water continued to increase and rainfall below normal, wells dug to increase reserve capac. of new system. Water from new system contains more CO_2 than that from old and will be treated with lime and soda ash. Water will be chlorinated until constr. work on system completed.—*W.P.R.*

Operation of the Cambridge, Mass., Filtration Plant. F. E. SMITH. J.N.E.W.W.A. **55:** 254 ('41). Acct. of addns. to purif. plant of Cambridge, Mass., in '32, and operating results since '30. Six new sand filters added to existing installation of 10 filters, making total capac. of plant 22.4 mgd. Water supply obtained from reservoir and pond. Color of mixed raw water varies from 17 to 65 ppm., turbidity low (2–3 ppm.), and raw water usually has musty odor. Content of coliform bacteria varies considerably; present in 0.1 ml. but frequently absent in 10 ml. Reservoir treated with copper sulfate when necessary to control growths of *Synura* and *Melosira*. Alum used for coagulation; results would be improved and load on filters reduced by longer periods of sedimentation; plans for addnl. settling tank prepd. Filter sand cleaned with caustic soda once a year. During winter months, difficulties caused by fine floc penetrating sand; resulting effluent contains 0.5–1 ppm. turbidity and 10–15 ppm. color and is of unsatisfactory bact. qual. Addn. of pond water to reservoir water produces stronger,

coarser floc; other measures adopted described. Tastes, odors and CO_2 removed from raw water to some extent by aeration. Lime added to filtered water to maint. pH value of 8.8 for prevention of corrosion and "red water"; treated water hardness 45 ppm. Table gives anals. of effluent from '35 to '39. Costs discussed.—*W.P.R.*

Report of Water and Sewer Commissioners, 1941, City of Medford, Mass. Total consumption for yr. for pop. of 63,540 equaled 1,325 mil.gal., of which 825 mil.gal. low service and 499.9 mil.gal. high service. Avg. consumption of 3.63 mgd. equal to 57 gal. per capita. Pipe in system of cement and c-i., ranging in size from 2" to 20"; total mileage in use, 114.3; system extended 2,966' during yr. Hydrants in use increased by 9 in yr., total equals 1149. Pressure range: 35 to 105 psi. Total services in use, 11,066, with 96 added during '41; services 100% metered. Income from rates: $233,876, with total receipts of $252,017.—*Martin E. Flentje.*

CANADIAN WATER SUPPLIES—GENERAL

Progress and Prospects in Water Supply and Sewage Works. A. E. BERRY. Can. Engr.—Wtr. & Sew. **80:** 7 (Jan. '42). Lively interest in munic. projects developed as result of increased war needs, easier tax collections, and overlong delay in meeting requirements in pre-war era. In addn., greatly increased industrial activity and new housing schemes for wartime undertakings have placed added strain on existing facilities. Industries and military camps located far from municipalities have necessitated constr. of independent works. Wartime Housing Ltd., body representing Dominion Govt., undertaken constr. of no. of residential projects in various parts of Canada, and while houses are for temporary use only, water and sew. facilities of permanent nature. Even if houses removed, sites should be attractive for permanent dwellings of industrial plants. Developments in Ont. municipalities outlined. At Welland, washing equipment is of Palmer agitator type, first such installation in Canada.—*R. E. Thompson.*

Directory of Canadian Water Works Systems. ANON. Can. Engr.—Wtr. & Sew. **80:** 6: 38 (June '42). Reference data, including source of supply, pumping and purif. equip., distr. system details, consumption, pop. served, and names of officials, given for Canadian municipalities of 500 and greater pop. **Directory of Important Water Systems of Canada.** ANON. Eng. Cont. Rec. **55:** 15: 50 (Apr. 15, '42). Authoritative, up-to-date information regarding sources of supply, purif. processes employed, distr. system details, consumption, pressure maintained, pop. served, etc., given for Canadian municipalities with pop. of 1000 or more. **Directory of Water Works Officials of Canada.** ANON. Eng. Cont. Rec. **55:** 15: 68 (Apr. 15, '42). Names of engrs., supts. and comrs. in charge of Canadian water supplies.—*R. E. Thompson.*

Engineering and Economic Problems Involved in a Small Water Works System. GORDON A. MACDONALD. Can. Engr.—Wtr. & Sew. **80:** 10: 20 (Oct. '42). As terrain flat and subsoil clay, wells not satisfactory source of water supply in Port Lambton, Ont., situated on St. Clair R. Many residences, therefore, supplied by individual pumping units drawing water from river. As shore poln. increasing, however, due to discharge of sewage and increased river traffic, Ont. Dept. of Health asked that remedial measures be taken to safeguard health of community. Village extends 1.5 mi. along river and as munic. assessment does not exceed $100,000, impossible to install distr. system consisting entirely of 6" pipe, however desirable from standpoint of fire protection. System therefore made up of 6" c-i. mains, supplemented with short runs of 4", in central business section, and 2" galnized steel pipe to outlying sections. Intake is of 8" c-i. pipe, 140' long, terminating in 10' of water. To avoid frazil ice difficulties, water screened at pumping well instead of at mouth of intake. Only treatment employed is sedimentation (in pumping well) and chlorination. Automatic hypochlorinator installed for latter. Two elec.-driven centrifugal pumps, of 60 gpm. capac. at 33 psi., arranged for operation individually, in parallel or in series. Series operation required to meet demands of summer colony. Pump operation controlled by pressure in 750-gal. tank in which air cushion maintd. by small compressor, belt-driven from one of pumps. Differential is about 6 psi. Cost, exclusive of house services, $15,500.—*R. E. Thompson.*

New Reservoir at Windsor Increases Storage Capacity. ANON. Eng. Cont. Rec. **55:** 30: 15 (July 29, '42). Increase in water consumption in Windsor to peak of 22.9 mgd. necessitated construction of new filtered water

reservoir. Reinforced concrete structure 199′ long, 189′ wide and 11′ deep has capac. of 2.3 mil.gal. It is adjacent to old reservoir, with which it will normally be operated in series.—*R. E. Thompson.*

Annual Report, Brockville, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 4: 7 (Oct. '42). Supply obtained from St. Lawrence R. and chlorinated. Of 3,158 consumers, only 50 metered. Consumption about 2.3 mgd. Profit on operation $12,048.52 and rebate of 2 months charge allowed consumers. No water works debt. Details of water rates included.—*R. E. Thompson.*

Annual Report, Chatham, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **4:** E: 12: 17 (Feb. '42). Water supply drawn from Thames R., and treated by filtration and chlorination. Pop. of city and suburbs 20,000. Avg. and max. daily consumptions 2.51 and 3.78 mil.gal. (U.S.), resp., and avg. per capita consumption 132 gpd. (U.S.). Distr. system comprises 45.6 mi. mains, 272 hydrants, 4,608 services and 4,800 meters. Alum used avgd. 1.71 gpg. (U.S.), ammonium sulfate 5 lb. per mil.gal., and chlorine 12.9 lb. per mil.gal. Max. turbidity 600 and min. 10 ppm. Cost per 1,000 gal. (Imp.): operation, 3.69¢; maint., 0.73¢; distr. system, 1.01¢; debenture payments, 1.07¢; office, insurance, etc., 0.99¢; meters, 0.48¢; flood relief and emergencies, 0.22¢; total, 8.19¢. Revenue 16.67¢ per 1,000 gal. Pressure maintd. for domestic service 60 and, for fire service, 110 psi.—*R. E. Thompson.*

Annual Report, Dorval, Que., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **4:** E: 13: 18 (May '42). System established in '12 and operated by munic. council. Supply derived from L. St. Louis (Ottawa R.) and treatment consists of coagulation, rapid sand filtration and chlorination. Consumption, by pop. of 2,500, avgd. 0.62 mgd. (Vols. are expressed in U.S. gal.) Of this, 92.3% used by domestic consumers (228.5 gpd. per capita). Filter runs ranged from 44 to 11 hr. and avgd. 28 hr., while wash water used avgd. 4.4% of water filtered. Rate of filtration 2 gpm. per sq.ft. On basis of designed capac., retention period in coagulation basin 2 hr. 40 min., but avg. retention 5.5 hr. Alum dosage varied from 2 to 3 gpg. and avgd. 2.53. Chlorine dosage ranged from 3 to 5 lb. per mil. gal. and avgd. 4. Color reduced from avg. of 50 to 5 ppm. Turbidity of raw water ranged from 0 to 45 ppm. and that of filtered water from 0 to 5 ppm. Treatment lowers pH from 7.0–7.5 to 5.5–6.3. Avg. purif. cost per mil.gal. $18.42, including $6.98 for alum and $0.44 for Cl_2. Avg. revenue per domestic service $17.50, equivalent to $4.20 per capita. Min. bill $6.50 per service.—*R. E. Thompson.*

Annual Report, Hamilton, Ont., 1940. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 6: 10 (Oct. '42). Pop. 155,836. Supply derived from L. Ontario and treated by filtration and chlorination. Avg. pumpage about 20.5 mgd. and max., 26.3; avg. per capita use 131.9 gpd. Pressure in mains avgd. 85 psi. Raw water turbidity exceeded 25 ppm. on 18 days and reached max. of 200 ppm.; avg. coliform bacteria content per 100 ml. was 9.9 and max. 500. No coliform organisms found in applied, filtered or tap waters during yr. Ammonium sulfate and chlorine dosages 0.05 and 0.2 ppm., resp., prior to filtration, and 0.1 and 0.3 ppm., resp., after filtration. Alum used as coagulant. Filter runs varied from 7.5 to 72 hr. Filters washed when loss of head reaches 8′, with max. of 72 hr. between washes. Total operating cost, including debentures and depn., equiv. to $4.92 per capita per yr., or 10.2¢ per 1000 gal. Four reservoirs provide total capac. of 24.92 mil.gal., equiv. to 1.2 days supply at avg. pumping rate. About 11% of 40,147 services metered. —*R. E. Thompson.*

Annual Report, London, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 1: 1 (Oct. '42). Estd. pop., as of Dec. 31, '41, was 78,393. Avg. pumpage was 6.8 mgd. and per capita consumption 87 gpd. Services 100% metered and 77.2% of water pumped passed through meters. No. of consumers 19,464, equiv. to 94 per mi. of mains. Hydrants totaled 1,276, i.e., 6.2 per mi. of mains. Excess of revenue over operating expenses $220,812.10 and all customers allowed water service for 2-mo. period free of charge. Grand total net surplus to date after debt charges $986,858.64. Avg. monthly net bill $1.02 for domestic consumers and $7.54 for commercial users. Net debenture liability $223,902.96, or $2.86 per capita. Water rates per cu.ft. gross are: 66 ¢ for first 200 cu.ft., 11¢ for next 50,000 and 7¢ for all above that amt., with min. monthly bill of $1.11. Meter rental charged for large meters. Discount of 10%

allowed for advance payment. Hydrant rental $18 per yr. Outside consumers pay all costs for service installation and double city rates, except meter rentals.—*R. E. Thompson.*

Annual Report, Picton, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 5: 9 (Oct. '42). Supply drawn from bay on L. Ontario filtered and chlorinated. Of 1,084 consumers, only 51 metered. Revenue totaled $19,682.31 and expenditures $19,295.08. Consumption by air force station supplied 70.6 gpd. per capita (1-yr. period).—*R. E. Thompson.*

Annual Report, Stratford, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 2: 3 (Oct. '42). Supply derived from deep wells and requires no treatment. Pop. 16,878. About 15% of pumpage delivered through separate line to railway. Per capita consumption (city) 96 gpd. Nearly 95% of services metered. 14′ of main per capita and 8.2 valves per mi. of mains. Rates vary from 15¢ per 100 cu.ft. for first 500 cu.ft. to 4.5¢ for all in excess of 10,000, less 10% for prompt payment. Min. monthly bill 50¢ gross. Cost of water per mil.gal. pumped, $7.18, while revenue $12.48. Revenue for yr. $58,151.79 and profit $6,631.52.—*R. E. Thompson.*

Annual Report, Woodstock, Ont., 1941. ANON. W.W. Inf. Exch.—Can. Sec. A.W.W.A. **5:** E: 3: 5 (Oct. '42). Supply derived from wells and springs. 3,749 consumers, 188 metered. Avg. consumption about 1.8 mgd. Operating surplus, $13,171.40. New low rates, to be placed in effect Jan. 1, '43, will reduce revenue $11,000 per annum. Details of new rate structure included.—*R. E. Thompson.*

FOREIGN WATER SUPPLIES—GENERAL

Mexico City Water Supply. A. VILLAREAL. Southwest W.W.J. **23:** 15 (Aug. '41). Present water supply system started in '05, serving pop. of 360,000 at max. rate of 554 gal. per sec. from southern springs called "Xochimilco." This system, with some improvements, sufficed until '13 when, due to indus. expansion and pop. increase, supply became inadequate making it necessary to start intermittent service. System then increased to capac. of 746 gal. per sec. and wells drilled which discharged directly into aqueduct and distr. system, thus extending service over more hours. In '34 work started to mend and replace part of concrete aqueduct damaged by earthquakes and earth movements to such extent that loss of 30% of flow was suffered. Part of line replaced by 48″ c-i. pipe. Addnl. improvements made until, at present, system supplies 1,000 gal. per sec. to pop. of 1,200,000. Immediate plans call for increase to 1,550 gal. per sec. by improvements to present system and drilling of 50 additional wells. Plans for future development over period of years will be put in operation as needed.—*P.H.E.A.*

Study Commissions. MIGUEL GUERRERO. Bol. Obras Sanit. Nacion (Arg.) **5:** 622 (Dec. '41). Gathering of field data to be used in prepn. of designs and cost ests. for water supply and sewerage projects in localities invoking benefits of national sanitation laws intrusted to study commissions. Coms. obtain description of existing installations, appraise urgency of required improvements and gather information on rainfall, runoff, climatic conditions, location of present and prospective sources of water supply, their yield and flow fluctuations, use made of the water above intake and below sewer outfall, pop. to be served, its distr. and growth rate, water consumption, location of existing industries and character of their wastes, prevalence of water-borne diseases, periods and intensity of epidemic outbreaks, existence of other afflictions such as goiter and mottled enamel attributable to the lack or excess of certain chem. substances in water, availability and cost of labor and bldg. materials, estn. of property values and any other physical, political, social and economic data useful in adequate soln. of problems involved. Water, sewage and soil samples always sent to central lab. of anal. and advice of geologists, chemists, bacteriologists, city planners, doctors and army men sought when required in soln. of special problems. Often com.'s personnel called upon to improvise simple devices for obtaining field information. Another important duty to obtain essential data for prepn. of topographic maps and profiles needed in selection of sites for intakes, reservoirs, water and sewage treatment plants and layout of water distr. and sewerage systems.—*J. M. Sanchis.*

Special Features of Water Filtration Plants in Colombia. C. S. DE SANTAMARIA. Can. Engr.—Wtr. & Sew. **80:** 22 (Feb. '42). Whereas only few cities in Colombia, S.A. had good public water supplies and none employed purif. processes 20 yr. ago, now nearly all large cities have both water and sewage systems. Country very mountainous and many water courses flow to sea through steep valleys formed of brittle or soft soils. Hence rainfall produces wide variations in water qual. and water purif. plants must be designed to cope with these sudden changes. Alum and lime or soda ash usually employed for coagulation, other chems. being too expensive. Most plants have mixing devices and some equipped with flocculators. Both gravity and pressure sand filters employed, former being preferred. Either water alone or air and water used for backwashing. Aeration widely practiced. Chlorine, with or without ammonia, employed for sterilization. Most plants equipped with labs. More important installations listed, capacs. varying from 2 to 22 mgd.—*R. E. Thompson.*

Experiences in the Construction of a Water Works Using Surface and Ground Water. J. WOLBER. Gas u. Wasser. (Ger.) **84:** 257 ('41). In 1886 town in west of Germany constructed water works drawing supply of river water from shallow wells on banks of Ruhr. After some years, extensions necessary, but by this time dam had been built in Ruhr below and accumulating sludge had decreased porosity of banks; increase in industry higher up Ruhr had caused considerable poln. of river with org. matter and phenol, and chlorphenol tastes appeared in water after chlorination. Treatment with active carbon not entirely successful. In '30–31 decided to give up existing supply and use ground water and bank-filtered water from Ruhr and stream, collected by infiltration gallery. Although test pumping did not greatly lower level of ground water, pumping of total requirements of 22,000 cu.m. per day caused rapid lowering. Increasing ground water supply by seepage from backwater of Ruhr increased bacterial count and caused reappearance of chlorophenol tastes. Infiltration gallery therefore increased in length, backwaters of Ruhr filled up, and pits from which material dug prepd. for use as seepage ponds to increase supply of ground water. One seepage pit fed from stream dredged down to gravel layer. By these means and heavy pumping, yield increased to 28,000 cu.m. per day, but water plumbosolvent and contents of carbon dioxide, manganese and iron very high. Trouble caused in laundries and yeast factory by manganese. Seepage from pits also rapidly decreased. Gravel strata contained much iron pyrites in parts. Lowering of the ground water level brought this into contact with atmosphere and weathering produced limonite and sulfuric acid. Acid combined with insoluble manganese oxide in gravel to form soluble manganese sulfate. Therefore important to avoid lowering level of ground water. Second infiltration gallery added and, as infiltration from Ruhr decreased by control of floods which normally washed banks, arrangements made to divert Ruhr water to lower part of stream. Tests showed that by this method rapid rise caused in ground water level and supply to infiltration galleries increased. Reconstructed supply system in operation since '38. Contents of iron and manganese now negligible and corrosive action of water decreased until de-acidification plant now unnecessary. Although water continuously chlorinated, no chlorophenol tastes now caused.—*W.P.R.*

Water Supply in 1941. ANON. Surveyor (Br.) **101:** 23 (Jan. 16, '42). Slide at Fort Peck provided strong argument in favor of British methods of earth dam constr. No. of parishes in every county in England and Wales, provided with piped water supplies are: England, 69.3%, and Wales, 69.6%. Few investigations in dam design and constr. which were made known last year include: compaction with explosives, consolidation of clay, testing earth dam materials, Fort Peck Dam, landslides and clay seams. In field of water purif., made evident that engrs. far from unanimity with respect to treatment of water supplies. Safety of water supplied for domestic consumption should not depend upon final chem. treatment, but should be conserved by adequate protection of sources. Trends of Am. practice in regard to sterilization express less divergence of opinion, while co-ordination of ideas and experiences seems to be more regional than national. Inter-system connection of water supplies mainly accomplished last year. Most new works and extensions, though accentuated by wartime conditions, normal development. Little of last year's activities can be recorded.—*H. E. Babbitt.*

Rural Water Supplies. *Proposals of the Committee on Land Utilization in Rural Areas.* ANON. Wtr. & Wtr. Eng. (Br.) **45:** 140 (Oct. '42). In June '39, out of 11,186 parishes in England and Wales, 3,342 were without piped water supplies. Piped water supply considered essential service in every village, on every farm, and a desideratum in every dwelling. Recommended that Ministries of Health and Agric. review position of water supply from national point of view with special reference to: (1) provision of supply to all towns and villages; (2) what reorganization of areas of supply may be needed; (3) consideration of dual use of gathering grounds, especially for afforestation or hill sheep farming and rules governing public access; and (4) facilitation of piped supply to farms, market gardens and allotments. Evidence received that certain water companies have used privileged position to take action which might have been modified to serve better national interests. Siting of reservoirs, acquisition of finest land in country, prohibition of access to areas and conditions imposed as to supply mentioned in evidence. Position with regard to rights-of-way should be examd. so that elec., gas and water supply undertakings should be placed on comparable footing.—*H. E. Babbitt.*

The Protection of Surface and Subterranean Sources of Water Supply. EDGAR MORTON. Off. Circ. Br. W.W. Assn. **24:** 189: 62 (Feb.-Mar. '42); Wtr. & Wtr. Eng. (Br.) **45:** 20, 54 (July, Aug. '42). Problem of protection one which involves joint responsibility of both water and san. engrs. Relative degree to which any source liable to poln. commonly dependent on geol. circumstances. Catchment areas of impounding reservoirs purchased outright and only permissible use of land for sheep grazing. Where water authorities do not exercise direct control they may be legally empowered to exercise partial measure of control by local ordinances controlling forms of drainage or "prevention of any act or thing tending to poln. of water." Similar problems of protection encountered in connection with service reservoirs. Contamn. of water in service reservoirs not infrequent. Water authorities may purchase subterranean gathering grounds to secure same measure of protection as in case of surface catchment. Shallow supplies liable to be affected by field drains, nearby farmyards, etc. Protection obtainable by purchase of land in neighborhood. In subpervious areas, where well bored through impervious clay, little risk of poln. from surface sources. If well situated close to outcrop, however, poln. may travel some distance underground, especially along fissures in chalk and limestone formations. While it may not be possible entirely to restrict development of land forming subterranean gathering grounds, such land can often be reserved solely for agric. use without compensation of landowners.—*H. E. Babbitt.*

New Works for Water Undertaking in the East Midlands. ANON. Wtr. & Wtr. Eng. (Br.) **43:** 337; **44:** 5 (Dec. '41; Jan. '42). Improvement scheme involves laying of approx. 5 mi. of 24″ and 1 mi. of 18″ mains, oil-engine pumping plant at west plant (*W*), electric-driven pumping plant at east plant (*E*), together with steam-driven generating plant as standby, and constr. of 2.5 mil.gal. (Imp.) reinforced concrete storage reservoir. Supply requirements (in Imp. gal.) include: (1) max. hourly demand during '36, 163,000; (2) avg. daily consumption in '35, 1,911,000; (3) daily avg. during week of max. demand, 2,215,000; (4) estd. future daily demand, 30 yr. hence, 3,689,000; (5) max. hourly demand, 2 × 154,000; and (6) min. available supplies—*W*, 120,000 and *E*, 100,000. Unfortunately no land in immediate vicinity to enable constr. of service reservoir with top water level to give adequate water pressure. To avoid subjecting 2 existing 18″ mains to excessive pressure, approx. 5 mi. of 24″ main laid. Min. cover of 3′ specified for mains. Whole length of mains laid sterilized with chlorine. Frequent hydraulic tests applied during laying, test pressures ranging between 100 and 120 psi. Bored reinforced concrete piles constructed (for pumping station foundation) with avg. length of 12′ to rock. Main walls of pumphouse of brick. Machinery includes 3 diesel oil engines, centrifugal pumps and lighting and compressor sets. Chlorination plant installed under War Emergency Measures. *E* pumping station bldg. designed to suit eng. requirements, preserve site amenities, and tone with old station. Machinery includes low- and high-lift pumps and motors, with auxiliary equip. Excellent results achieved. —*H. E. Babbitt.*

War Manpower Commission Policy and Manning Tables

THE statement of War Manpower Commission policy which follows is recommended study material for all association members. It should be combined with a review of the summary of British Manpower policy which appeared in the News of the Field of the December (1942) JOURNAL.

Public water supply operations and personnel are included in group 30 of the list of civilian activities essential to the support of the war effort.

The extent of use of occupational bulletins by local draft boards will undoubtedly depend upon reference to them by employers or employees who wish to obtain deferments. Therefore this release from the Manpower Commission needs to be studied as well as other articles upon the subject that have appeared in previous issues of the JOURNAL—if public water supply employees are to be retained in this essential civilian service.

War Manpower Commission Release No. PM–4201, December 9, 1942

The bosses of the nation's war plants and essential activities are used to working from blueprints in planning and working out their production problems. Now the War Manpower Commission and the Selective Service System are helping them to draw up blueprints from which they can plan and work out their prime manpower problem.

The blueprints will be manning tables, to be distributed by the regional offices of the War Manpower Commission on request to employers whose plants are engaged in at least 75 per cent war production or who are performing some essential service such as are the public utilities, the railroads, etc. These tables will be widely in use within the next few months.

The manning tables are forms, which, when filled out, provide a realistic inventory of the personnel and job classifications in each plant. They determine how efficiently a plant is utilizing its working force, how adequate are its programs for training, upgrading and promoting employees, and provide a basis for planning improvements. They will provide each employer in many cases for the first time, with complete information as to the number of employees who are subject to induction. A supplementary withdrawal and replacement schedule will offer him guidance in planning replacements so that his production will not suffer as his employees enter military service.

The manning tables, which may seem technical and involved at first glance, actually are neither. They are forms which are relatively simple to fill out, and which offer a sensible method of evaluating the personnel and produc-

tion problems of each plant and the best method of meeting them.

The employer must expend some time and effort in gathering the required information, but will in return receive information which will enable him to plan adequately to meet his labor needs of the future. The Government will, in turn, receive information which will furnish the basis for the orderly withdrawal of workers, who must, under Selective Service, be released to the armed services.

The manning tables are one part of a four-part plan by which the War Manpower Commission and Selective Service intend to meet the withdrawal of inductees from industry through the planned training of replacements in a manner which will keep disruption of production at an absolute minimum. The other parts are:

1. The drawing up of a list of 35 industries designated as "essential activities," which are as follows:

Production of Aircraft and Parts
Production of Ships, Boats and Parts
Production of Ordnance and Accessories
Production of Ammunition
Agriculture
Processing of Food
Forestry, Logging and Lumbering
Construction
Coal Mining
Metal Mining
Nonmetallic Mining and Processing and Quarrying
Smelting, Refining and Rolling of Metals
Production of Metal Shapes and Forgings
Finishing of Metal Products
Production of Industrial and Agricultural Equipment
Production of Machinery
Production of Chemicals and Allied Products
Production of Rubber Products
Production of Leather Products
Production of Textiles
Production of Apparel
Production of Stone, Clay and Glass Products
Production of Petroleum, Natural-Gas and Petroleum and Coal Products
Production of Finished Lumber Products
Production of Transportation Equipment
Transportation Services
Production of Materials for Packing and Shipping Products
Production of Communication Equipment
Communication Services
Electric Light and Power, Water and Gas Utilities; Steam Heating Companies
Repair Services
Health and Welfare Services
Educational Services
Governmental Services (Other Than Federal)
Technical, Scientific and Management Services

2. The prepartion of a list of the essential jobs—approximately one out of each nine—within each of these industries. This list should be completed by December 31, 1942, and will include 3,000 classifications.

3. The preparation of withdrawal and replacement schedules to be based on information compiled in the manning tables. Where plants are facing a critical situation requiring immediate atention, these schedules may be prepared and put into effect before the manning tables.

The four parts fit together neatly. The lists of essential industries and

jobs aid local Selective Service boards in determining which jobs should be reason for deferment. The lists are elastic and can be lengthened or shortened as circumstances dictate.

The aim of the whole program is to enable each plant to deal with its personnel problem in the most orderly, informed and adequate manner.

The first step taken was to determine which industries were essential to the nation's war effort. This done, the War Manpower Commission studied the jobs within each industry and separated the essential ones from the others by applying the following three questions as a test:

1. Is a training period of at least six months necessary before an untrained worker can attain reasonable efficiency in the job?
2. Is the job essential to the industry?
3. Is the worker irreplaceable?

The job was rated essential if a "yes" answer was given to all three questions.

The local Selective Service boards can use these lists to check against any request by an employer for deferment of a worker whom the employer declares to be essential, pending completion of the withdrawal and replacement schedules.

Such deferments, usually granted for a six-month period, do not mean exemption from the draft. Such workers, if fit for military service, are granted deferment only long enough to enable their employers to train someone to replace them.

In the past, however, replacements have been more the exception than the rule. Employers have not trained replacements in an adequate fashion and have had no way of knowing how rapidly men would be taken. Some have even made the mistake of training replacements who were themselves subject to induction.

Local boards are accustomed to dealing with each case as an individual. There have been cases when local boards, each unaware of what the other was doing, took so many men from a single department of a plant at the same period that production was disrupted. It has been obvious that some more co-ordinated method was needed for planning both withdrawals and replacements. To meet this need, the manning tables and the replacement schedules were worked out.

In addition to the usual routine information, these manning tables ask each employer to provide the following information:

1. The different kinds of jobs in the plant or activity.
2. The number of workers necessary to do each kind of job.
3. The type of worker suited to do each job and the possibility of substituting other workers of less skill.
4. The amount and kind of training needed to train an unskilled worker to do each job.
5. Training methods being used or available.
6. The jobs in which women are employed and those in which women could replace men.
7. Indications of labor requirements that will accompany anticipated production program.
8. Job relationships, and possibilities for promotions and upgrading.
9. Balance or unbalance between number of skilled workers and unskilled, or of workers and supervisors.
10. Jobs where physically handicapped persons can be used.

EXAMPLE - A

REPLACEMENT SUMMARY
List of Jobs - Selective Service Status of Workers

Budget Bureau No. 33-R044-42
Approval Expires June 30, 1943

Company _____ Date _____ 19____

Plant _____ Signed _____

Location _____ Title _____

Line No. or Code	LIST OF JOBS (Job Titles)	Number of Women	Number of Men not now to be considered for Replacement on Example - B					Number of Men to be considered for Replacement on Example-B			Total of All Workers	Anticipated Maximum Number of Workers (Optional)
			Men With Minor Children	Class 4-F	Over Age	Under Age	Total	Single Men	Married Men Without Children	Total		
1	2	3	4	5	6	7	8	9	10	11	12	13
	DETAIL MFG. DEPT.											
	MACHINE SHOP											
	Foreman		5		2		7		1	1	8	
	Sub-Foreman		6	1	3		10	2	3	5	15	
	Leadman		19	1	9		29	6	2	8	37	
	Milling Machine Oper.		20	2	15		37	10	11	21	58	
	Automatic Screw Machine Oper.		10	2	6	1	19	8	21	29	48	
	Engine Lathe Oper.		7	3	7	3	20	27	11	38	58	
	Drill Press Oper.	42	20	5	10	61	138	32	41	73	211	
	Assembler "C"	824	550	69	179	231	1,853	237	294	531	2,384	
	ENGINEERING DEPT.											
	Chief Engineer				1		1				1	
	Administrative Engineer		1				1				1	
	Project Engineer		3		1		4		1	1	5	
	Layout Draftsman		16	2	12		30	8	14	22	52	
	Detail Draftsman	38	15	11	21	13	98	61	41	102	200	
	Expediter		3	1			4	1	1	2	6	
	Stock Clerk		4	1		1	6	3	5	8	14	
	Stock Chaser		4	1		3	8	11	8	19	27	
	TOTALS	4,515	3,403	422	1,797	1,290	11,427	1,643	1,772	3,501	14,928	

EXAMPLE - B

REPLACEMENT LIST
List of Employees - Anticipated Replacements Per Month or Period

Budget Bureau No. 33-R044-42
Approval Expires June 30, 1943

Company _____ Date _____ 19____

Plant _____ Signed _____

Location _____ Title _____

Line No. or Code	Job Title	Name	Year of Birth	Sel. Ser. Class.	Married or Single	Local Board No. County State	Order No. (opt)	We will be prepared to replace these men within the month or period checked below							
								1st	2nd	3rd	4th	5th	6th	6 to 12 Mos.	Over 12 Mos.
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
	DETAIL MFG. DEPT.														
	MACHINE SHOP														
1	Foreman	Smith, John R.	'04	II-B	M	-									✓
2	Sub-Foreman	Jones, Thomas L.	'09	III-B	S	-				✓					
3		Wilson, Jeffry B.	'12	III-A	S	-					✓				
4		Bradon, John R.	'11	II-B	S	-						✓			
5		Waite, Tim	'17	II-B	M	-							✓		
6		Mann, Joseph W.	'17	II-B	M	-								✓	
7	Leadman	Nichols, Roger	'15	III-A	S	-		✓							
1463		Colgan, Douglas	'22	Uncl.	M	-							✓		
	ENGINEERING DEPT.														
1464	Project Engr.	Evans, John T.	'99	III-B	M	-									✓
1465		Allan, B. C.	'07	II-B	S	-			✓						
1466	Layout Draftsman	Martin, Chas.	'09	II-B	S	-			✓						
1467		Park, Franklin	'09	III-A	M	-				✓					
1468		Davis, Donald K.	'14	II-B	M	-				✓					
3499	Expediter	Furman, Oliver S.	'14	II-B	S	-					✓				
3500		Winter, Wm. C.	'17	III-A	M	-								✓	
3501	Stock Clerk	Honan, W. H.	'21	I-A	S	-		✓							
		TOTALS						167	100	100	100	150	150	1250	1484

The company retains one copy of the complete table and sends four to the WMC regional office. The regional office keeps one and sends a copy each to the State Director of Selective Service, the War Manpower Commission in Washington, D.C., and the local Director of the United States Employment Service.

After drafting the manning table, the employer will draw up a replacement schedule to direct him in upgrading, promoting and recruiting replacements for workers which the compiled information shows him will soon be inducted. When the replacement schedule has been accepted by the state director of Selective Service, the employer will be authorized to use a state acceptance number on forms 42-A filed in accordance with the accepted replacement schedule. The employer will fill out an affidavit—Occupational Classification Form 42-A—for all employees within the ages liable to military service for whom occupational deferment is then necessary.

It will not be necessary at the present time for employers to file such affidavits for employees who have wives and children with whom they maintain a bona fide family relationship. The employer will, however, file a Form 42-B for such employees.

These forms 42-A and 42-B are then forwarded to the local Selective Service Boards concerned. When the employee is classified or reclassified, the local board will notify the employer.

This system will enable each employer to know not only how many employees will be withdrawn from each department of his plant but will know approximately when the withdrawal of a worker will occur and will be able to plan his replacements accordingly. The War Manpower Commission will assist the employer in every way it can to make such replacement and will advise him and aid him in locating women, older workers and handicapped workers to replace inducted employees as well as in training and upgrading programs.

Once the manning tables and replacement schedules are in operation, deferment of workers will be subject to periodical review.

The policy behind the manning table is explained by Paul V. McNutt, Chairman of the War Manpower Commission.

"In total war," Mr. McNutt said, "each person in the nation should perform, as nearly as possible, the task for which he is best equipped. The War Manpower Commission and the Selective Service System both recognize this principle. Both trained fighters and trained workers are essential to winning the war.

"The needs of the armed forces eventually will compel the induction into active military service of practically all men who can meet age, physical and other requirements. These men must be released by industry. The manning table plan provides the basis for the withdrawal of such workers at a rate that will permit the training of replacements not suitable for active service."

It will take a few months, however, to get the manning tables in operation. In the meantime, looming inductions may create situations in some plants which require immediate action. To offer a temporary solution in such cases, the Selective Service directors in each state now have the withdrawal and replacement schedule forms which are available to such employers upon request. These schedules will provide a basis for withdrawals and replace-

ments pending completion of the manning tables.

These schedules consist of a plant summary and a replacement list, normally made from data developed in preparation for the manning table. They are in two parts. The first part is made up of a survey of the personnel in the plant involved, arranged generally by job titles and Selective Service statuses. The second part is a replacement list upon which are listed by name the male employees who must be replaced so they can enter the armed forces.

The first step in preparing such a schedule is to secure in respect to each male employee the following information: (1) job title, (2) date of birth, (3) local board number and address, (4) Selective Service order number and classification and (5) family relationships.

Next, the employer must list all of the jobs by plant, department and other operating unit. Opposite each job the employer will list under the following headings the total number of workers engaged: (1) number of women, (2) number of men not to be considered for replacement (those with minor children, those physically unfit, those over 38 and under 18), and (3) those to be considered for replacement (single men and married men without children).

The employer will then list by name the employees subject to induction whom he is prepared to replace. Those who are to be replaced in the first month will be listed first, followed by those in the second month, etc. Those men for whom deferment is to be requested for six months or more will be listed under "6 months to 12 months" and those for whom deferment is asked for a year will be listed last under "more than one year." These facts, which will provide an impersonal and impartial yardstick, will be considered in determining the order of listing:

1. Required period of training.
2. Previous and existing periods of deferment.
3. Availability for military service (single men will be listed ahead of married men.)
4. Selective Service order numbers (those with the lowest order numbers usually will be listed first).

When a schedule has been thus prepared and approved by the state Selective Service director, it shall, unless revised, continue in operation for six months.

These schedules, once completed will show to the employer and to the employee the order in which each individual concerned will be available for induction.

At the end of the six-month period the replacement schedule may be extended for another six-month period with the approval of the state director of Selective Service.

If, however, the employer has filed a replacement schedule which is not based upon a manning table, the regional WMC director may decide that the employer should be required to make out a manning table before submitting a new replacement schedule. In such a case the WMC regional director will notify the state Selective Service director of his belief at least 60 days in advance of the expiration of the schedule in effect. The state director will inform the employer of the WMC action. If the employer declines to prepare a manning table, the state director may refuse to renew the employer's schedule.

In case the state director should feel the existing schedule should be renewed despite the WMC action, he will so notify the Director of Selective Service who in turn will submit the matter to the chairman of the War Manpower Commission for a ruling.

The question of deferment on occupational grounds in each individual case will continue to rest with the local board of appeals. Local boards, however, will give serious consideration to the replacement time which has been determined under an accepted replacement schedule. The employee retains his right to appeal.

In cases where an employer does not fill out either a manning table or a replacement scheule, deferments and inductions will be ordered by the local Selective Service boards in the same manner as in the past.

Discharge of Soldiers Over 38 Years of Age

EMPLOYERS and soldiers themselves must initiate action to obtain honorable discharges from the Army of soldiers over 38, to return to essential war industry jobs, including agriculture, according to the Office of War Information Release 993, dated December 21, 1942.

The jurisdiction and authority for such releases rest entirely with the Army, civilian agencies having no jurisdiction in the matter.

The Army regulation, announced in War Department Circular No. 397, after the President, on December 5, stopped induction of men of 38 or over, specifies that "certain enlisted men now in the Army who by reason of age (38 years and over), are unable to satisfactorily perform military service but who are qualified to assist the national war effort, may be honorably discharged from the Army in accordance with the following provisions:

"a. The soldier has voluntarily requested discharge in writing to his immediate commanding officer.

"b. The soldier is handicapped by advanced age, 38 years and over, to such an extent that his usefulness to the Army is secondary to that of industry.

"c. The soldier has presented satisfactory evidence that he will be employed in an essential war industry, including agriculture, if he is discharged from the Army.

"Each application for discharge under the above conditions will be considered on its individual merits and no soldier will be discharged unless a suitable trained replacement is present and available."

It is to be noted carefully that the above refers to soldiers and the Army. The Navy has made it clear that it considers navy men to have enlisted for the duration or more as the case may be, and that the Army program for discharging men over 38 does not obtain for the Navy.

TITLE 32—NATIONAL DEFENSE

Chapter VI—Selective Service System

[*Amendment 111, 2nd Ed.*]

Part 626—Reopening and Considering Anew Registrant's Classification.

Occupational Certification

By virtue of the provisions of the Selective Training and Service Act of 1940 (54 Stat. 885, 30 U.S.C., Sup. 301–318 inclusive); E.O. No. 8545, 5 F.R. 3779, E.O. No. 9279, 7 F.R. 10177, and the authority vested in me by the Chairman of the War Manpower Commission in an Administrative Order dated December 5, 1942, Selective Service Regulations, Second Edition, are hereby amended in the following respect:

1. Amend the regulations by adding a new section to be known as 626.2–1 to read as follows:

626.2–1 *Action of Local Board when Occupational Certification is on file in Registrant's Cover Sheet.* When the local board, upon review at any time, determines that a registrant should be considered for classification into a class available for military service and an Occupational Certification (Form 42B) is on file in the registrant's Cover Sheet (Form 53), it shall (1) notify the employer by detaching and mailing to him the Notice to Employer of Reopening Classification portion of the Occupational Certification (Form 42B) and (2) allow the employer 15 days from the date it mailed such notice in which to file an affidavit—Occupational Classification (industrial) (Form 42A).

2. The foregoing amendment to the Selective Service Regulations shall be effective immediately upon the filing hereof with the Division of the Federal Register.

LEWIS B. HERSHEY
Director

December 22, 1942.

[F.R. Doc. 42–13759; Filed, December 23, 1942; 9:17 a.m.]

Editor's Note: Forms 42A and 42B are available at all local draft boards. The text of Form 42A was given in a special mailing to all members on July 15, 1942. See page 1591 of the October 1942 JOURNAL for Gen. Hershey's advice on long-term personnel planning.